

ESTIMATING EXPECTED HEALTH OPPORTUNITY COSTS IN THE NHS

(Analysis of 2005/06 Expenditure Data)

YORK TEAM

Contents:

• Summary of Appendix 1	2
○ Table 1 Outcome and expenditure elasticities for 2005/06, 2006/07, 2007/08, 2008/09 and 2009/10	6
• Summary of Appendix 2	7
○ Table 2 Probabilistic results for 2005/06 compared to previously generated results	8
○ Figure 1 Results illustrating uncertainty for 2005/06 and previously generated results – cost per QALY	9
○ Figure 2 Results illustrating uncertainty for 2005/06 and previously generated results – Health opportunity costs of £10mn (QALYs)	9
○ Table 3 Sensitivity of results to estimated outcome elasticities	11
○ Table 4 Sensitivity of overall results to estimated spend elasticities	12
○ Table 5 Sensitivity of overall results to surrogacy and extrapolation assumptions	14
• Appendix 1 Outline of data update, estimation strategy, and results for outcome and expenditure models for 2005/06	15
○ Table A1 Outcome and expenditure elasticities for 2005/06, 2006/07, 2007/08, 2008/09 and 2009/10	19
○ Table A2 Nature of failure of previous year's specification when applied to the following year's data	25
○ Table A3 OLS specification for previous years and current year	26
○ Table A4 Preferred outcome specifications for 2005/06	27
○ Table A5 Preferred expenditure specifications for 2005/06	30
○ Table A6 Estimation path to preferred outcome specifications for 2005/06	34
○ Table A7 Estimation path to preferred expenditure specifications for 2005/06	38
• Appendix 2 Expected health opportunity costs in the NHS (2005/06 results)	45
• Appendix 2.1 Results	45
○ Table A8 Deterministic results for 2005/06 compared to previously generated results	45
○ Table A9 Probabilistic results for 2005/06 compared to previously generated results	46
○ Figure A1 Results illustrating uncertainty for 2005/06 and previously generated results – cost per QALY	47
○ Figure A2 Results illustrating uncertainty for 2005/06 and previously generated results – Health opportunity costs of £10mn (QALYs)	47
○ Table A10 Implied PBC cost per QALY ratios over time	48
• Appendix 2.2 Sensitivity analysis	49
○ Table A11 Sensitivity of results to estimated outcome elasticities	50
○ Table A12 Sensitivity of overall results to estimated spend elasticities	51
○ Table A13 Sensitivity of overall results to surrogacy and extrapolation assumptions	54
• Appendix 2.3 Outline of ONS data update for 2005/06	55
○ Table A14 Net YLL for 2005-2007, 2006-2008, 2007-2009, 2008-2010 and 2009-2011 using LE for each PBC	56
• Appendix 2.4 Comparison with overall NHS mortality elasticities	59
○ Table A15 Estimated overall elasticities	59

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 2005/06

Starting point: the 2006/07 specification

1. Identify the preferred specification for the outcome and expenditure equation for each programme budget category (PBC) for 2006/07. The outcome and expenditure elasticities generated by these specifications (when estimated at LA-level) are shown in Table 1.

Re-estimate the 2006/07 specifications using updated data

2. The 2006/07 specifications were derived using a combination PCT-level data mapped to LA-level and direct LA-level data. Backdate PCT-level data to 2005/06 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 2006/07 to 2005/06
- the raw population, unified weighted population, and MFF estimates used and implied by the resource allocations for 2005/06
- 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 (where possible).

Note that the PB data for 2005/06 was originally generated for the then 303 PCTs. This has been converted to the new 152 (since October 2006) PCT boundaries by the DH.

3. Obtain LA-level statistics for those variables that are reported at this unit of analysis. This will involve backdating LA-level data for 2006/07 to 2005/06. This will include backdating :

- mortality data for 2006/07/08 with data for 2005/06/07
- census-based variables for 2006 with data for 2005 (by appropriate interpolation between 2001 and 2011).

Complications: (i) no data for CKD prevalence for 2005/6 and 2006/7 so we use 2007/8 as a proxy for both years; (ii) prevalence rates for diabetes and epilepsy for 2005/6 are available by PCT but these rates are for the set of PCTs prior to the re-organisation in October 2006 (n=303). Without a mapper for this re-organisation, we use the prevalence rates for 2006/7 as proxies for the rates in 2005/6; (iii) a similar issue affects the IMD2007 and we have persevered with this here rather than investigating the IMD2004 (remember the IMD2004 uses data from 1997 to 2003); (iv) there were some relatively small boundary changes for local government in April 2009. Hitherto, our LA-level analysis has used this post-April 2009 geography. We persevere with this geography by adjusting the reported pre-April 2009 mortality rates so that they relate to the post-2009 boundaries as closely as possible.

More precisely, the re-organisation of local government created nine new unitary authorities (UAs). Five of these were created from existing county councils and their district councils. The remaining four new UAs were created by splitting Cheshire and Bedfordshire into two each along existing district council boundaries. The nine unitary authorities are, therefore, all aggregates of existing local authorities. Further details of the re-organisation are shown below:

- Bedford UA was formed from Bedford District Council.
- Central Bedfordshire UA was formed from Mid Beds and South Beds District Councils.
- Cheshire East UA was formed from Congleton, Crewe & Nantwich and Macclesfield District Councils.
- Cheshire West and Chester UA was formed from Chester, Ellesmere Port and Vale Royal District Councils.
- Cornwall UA was formed from the Caradon, Carrick, Kerrier, North Cornwall, Penwith and Restormel District Councils (i.e., equals Cornwall county council except the Isles of Scilly).
- County Durham UA was formed from Chester-le-Street, Derwentside, Durham, Easington, Sedgfield, Teesdale and Wear Valley District Councils (i.e., Durham county council).
- Northumberland UA was formed from Alnwick, Berwick-upon-Tweed, Blyth Valley, Castle Morpeth, Tynedale and Wansbeck District Councils (i.e., Northumberland county council).
- Shropshire UA was formed from Bridgnorth, North Shropshire, Oswestry, Shrewsbury and South Shropshire District Councils (i.e., Shropshire county council).
- Wiltshire UA was formed from Kennet, North Wiltshire, Salisbury and West Wiltshire District Councils (i.e., Wiltshire county council).

The transition of Bedford from a district council (DC) to a UA poses no problems for us as mortality data for all district councils are routinely reported by the HSCIC. Thus we can backdate our UA-level data using DC data.

There is an issue with Bedfordshire UA and the two Cheshire UAs. How do we combine the mortality rates for the two or three component DCs to reflect the post-2009 UA boundaries? Population estimates for these DCs are readily available for 2000 (latest available from the NOMIS website) so we used these as weights so that we could combine the DC mortality rates to form the estimated UA mortality rates. Ideally, of course, we would use mortality and population data by age group and year for each of these DCs for each of the study periods to form the relevant UA data. But this would be a considerable undertaking (even if we could get the data) and it is not obvious that such an exercise would involve a sensible use of project resources (not least because only three UAs are affected).

Finally, there is a very slight discontinuity with the Cornwall data. We use the Cornwall county council mortality data for pre-2009 as a proxy for Cornwall UA data. The difference here is that the

UA (population in 2000 is 495,400) excludes the Isles of Scilly (population 2,100) but the County Council includes it.

Estimation strategy for 2005/06: same as for 2006/07

4. Having backdated all data, use the preferred specification for 2006/07 to re-estimate each outcome and expenditure equation for 2005/06.
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 2006/07 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 2006/07 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 2006/07 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 2005/06: elasticities from preferred specifications

12. The estimation strategy outlined above generated the outcome and expenditure elasticities for 2005/06 shown in Table 1.

Results for 2005/06: 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 2005/06: estimation path to preferred specifications

14. The full estimation path for each result (starting with the re-estimation of the 2006/07 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 2005/06, 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	105***	A	-0.432	--	1205***	--								
2	Cancers and tumours	-0.345***	--	0.502**	A	-0.287***	--	0.784**	--	-0.273***	--	1626***	A	-0.239***	A	1219***	--	-0.159*	A	1592***	A								
3	Diseases of the blood	n/a		1060***	B	n/a		0.995***	--	n/a		1374***	--	n/a		1037***	--	n/a		1486***	--								
4	Endocrine, nutritional, metabolic	-1075**	A	0.708***	--	-1607**	--	0.498**	A	-1491	D	0.455***	--	-1464	A	0.630***	A	-1035	--	0.663***	--								
5	Mental health disorders	n/a		0.899***	--	n/a		0.995***	--	n/a		1103***	--	n/a		1143***	--	n/a		0.99***	--								
6	Learning disability	n/a		0.647**	B	n/a		0.329	--	n/a		0.386	--	n/a		0.410	B	n/a		0.449*	D								
7	Neurological problems	-1357	C	0.850***	--	-0.304	C	0.897***	--	-0.237*	B	0.733***	A	-0.869*	D	0.382*	A	-0.325	A	1220***	--								
8	Vision problems	n/a		0.934***	A	n/a		0.70***	--	n/a		1106***	C	n/a		0.93***	--	n/a		1127***	--								
9	Hearing problems	n/a		1273***	C	n/a		1637***	--	n/a		0.95*	A	n/a		0.989**	--	n/a		0.762**	--								
10	Circulatory problems	-1842***	--	0.494*	--	-1384***	--	1784***	A	-1315***	A	1614***	--	-1404***	--	1578***	--	-1637***	A	1477***	--								
11	Respiratory problems	-2.103***	B	0.576***	--	-167***	--	0.752**	--	-1564***	A	1555***	A	-2.28***	--	1287***	--	-2.217***	A	1225***	A								
12	Dental problems	n/a		0.765***	B	n/a		0.428**	B	n/a		0.420***	D	n/a		0.835**	C	n/a		See text	n/a								
13	Gastro-intestinal problems	-1989*	A	0.387*	--	-1146**	A	0.520*	--	-0.837**	--	1490***	A	-1255**	--	1014***	A	-1014*	--	1076***	--								
14	Skin problems	n/a		0.890***	D	n/a		0.907***	--	n/a		0.787***	--	n/a		0.70***	A	n/a		0.840***	A								
15	Musculo-skeletal problems	n/a		0.295	B	n/a		0.738***	C	n/a		0.733***	--	n/a		0.628*	A	n/a		0.935***	--								
16	Trauma and injuries	0	n/a	1090***	--	0	n/a	1344***	--	-0.638	n/a	1328***	--	0	n/a	0.705***	--	Tbc		0.897***	A								
17	Genito-urinary problems	-2.997	B	0.878***	--	-0.024	C	0.733***	--	-1977	C	1015***	A	-0.588	D	0.988***	A	-0.869*	A	1079***	--								
18	Maternity and reproductive health	-0.166*	B	0.653***	--	-0.030	A	0.963***	--	-0.057	--	0.563**	--	-0.085	C	0.614**	--	-0.056	B	0.865***	--								
19	Neonates																												
20	Poisoning and adverse events	n/a		0.658**	--	n/a		2.102***	--	n/a		1674***	A	n/a		1107***	--	n/a		1735***	--								
21	Healthy individuals	n/a		1246**	--	n/a		1049	--	n/a		1296**	C	n/a		0.709	B	n/a		0.507	B								
22	Social care needs	n/a		0.844	B	n/a		1192*	--	n/a		1669**	C	n/a		1702***	--	n/a		1069*	--								
23	Other (includes GMS/FMS)	n/a		0.564***	B	n/a		0.338***	--	n/a		0.553***	--	n/a		0.447***	A	n/a		0.532***	--								

Notes: (i) see pp3-4 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 (2005/06 results)

Overview

15. In the second appendix results are presented that reflect the available data for 2005/06 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 2005/06 compared to previously generated results

2005/06	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£7,613	£7,635	£5,611	£11,619
Health opportunity costs of £10mn (QALYs)	1,314	1,310	861	1,782
2006/07	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£6,844	£6,838	£5,139	£9,878
Health opportunity costs of £10mn (QALYs)	1,461	1,462	1,012	1,946
2007/08	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£9,747	£9,765	£7,689	£13,043
Health opportunity costs of £10mn (QALYs)	1,026	1,024	767	1,301
2008/09	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£12,960	£13,271	£8,390	£32,881
Health opportunity costs of £10mn (QALYs)	772	754	304	1,192
2009/10	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£9,887	£9,920	£6,802	£17,296
Health opportunity costs of £10mn (QALYs)	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 decreased slightly between 2006/07 and 2005/06 and so the cost per QALY ratio has risen. 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 2005/06 and previously generated results – cost per QALY

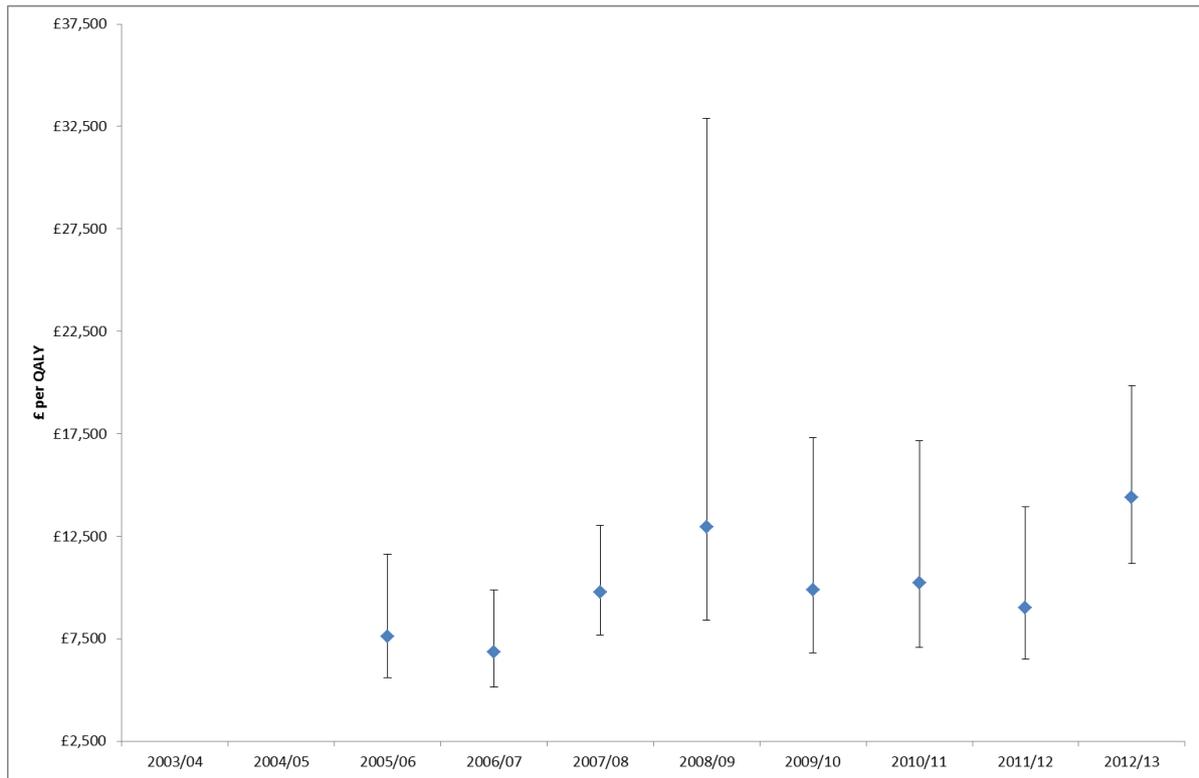
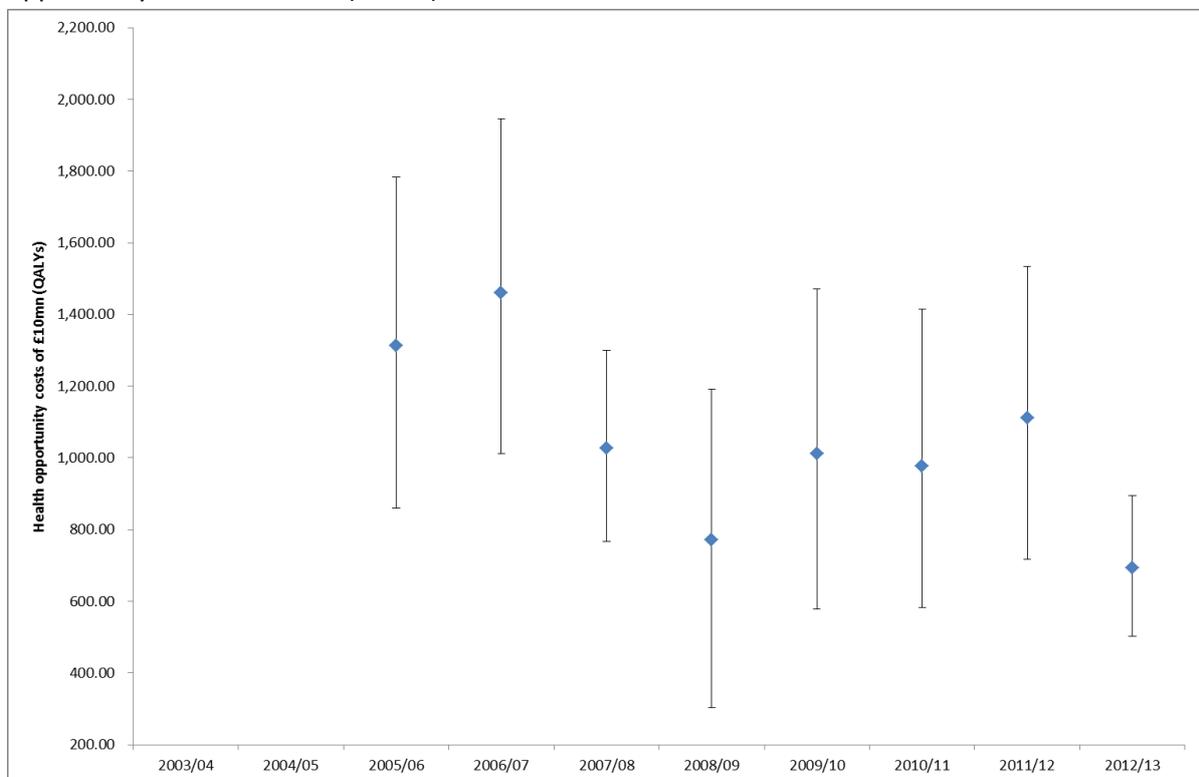


Figure 2 Results illustrating uncertainty for 2005/06 and previously generated results – Health opportunity costs of £10mn (QALYs)



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) 2006/07	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09
2	Cancer	£ 999,160.83	36	£ 27,667.77	55	4.22%	6	6	5	6
10	Circulatory	£ 1,383,957.98	286	£ 4,844.61	202	15.42%	3	2	3	4
11	Respiratory	£ 642,465.45	461	£ 1,394.46	405	30.81%	1	1	1	2
13	Gastro-intestinal	£ 659,566.93	66	£ 9,954.11	81	6.14%	5	4	4	5
1	Infectious diseases	£ 214,481.53	11	£ 19,452.54	22	1.68%	7	7	8	7
4	Endocrine	£ 186,239.98	64	£ 2,916.06	128	9.73%	4	3	2	3
7	Neurological	£ 377,639.63	81	£ 4,677.53	223	16.95%	2	5	6	1
17	Genito-urinary	£ 548,134.04	7	£ 78,439.80	12	0.92%	8	8	7	8
16	Trauma & injuries*	£ 516,775.76	0	N/A	-	-	-	-	-	-
18+19	Maternity & neonates*	£ 481,545.51	0	£ 7,526,403.52	0	0.02%	9	9	9	9
3	Disorders of Blood	£ 195,852.54	42	£ 4,703.82	-	-	-	-	-	-
5	Mental Health	£ 1,187,618.17	137	£ 8,673.25	-	-	-	-	-	-
6	Learning Disability	£ 157,547.24	2	£ 69,200.60	-	-	-	-	-	-
8	Problems of Vision	£ 239,937.18	11	£ 21,838.83	-	-	-	-	-	-
9	Problems of Hearing	£ 36,036.45	13	£ 2,675.78	-	-	-	-	-	-
12	Dental problems	£ 229,875.99	24	£ 9,432.19	-	-	-	-	-	-
14	Skin	£ 169,970.46	4	£ 46,661.01	-	-	-	-	-	-
15	Musculo skeletal	£ 526,833.06	65	£ 8,159.61	-	-	-	-	-	-
20	Poisoning and AE	£ 186,440.01	4	£ 49,191.19	-	-	-	-	-	-
21	Healthy Individuals	£ 100,068.37	0	£ 214,734.17	-	-	-	-	-	-
22	Social Care Needs	£ 270,712.47	0	N/A	-	-	-	-	-	-
23	Other	£ 689,140.42	0	N/A	-	-	-	-	-	-
Total:			1,314							

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) 2006/07	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09	
2	Cancer	£ 999,160.83	36	£ 27,667.77	46	3.52%	4	8	8	11
10	Circulatory	£ 1,383,957.98	286	£ 4,844.61	61	4.61%	2	9	2	2
11	Respiratory	£ 642,465.45	461	£ 1,394.46	133	10.11%	1	1	1	1
13	Gastro-intestinal	£ 659,566.93	66	£ 9,954.11	12	0.91%	12	18	12	13
1	Infectious diseases	£ 214,481.53	11	£ 19,452.54	9	0.69%	14	19	21	19
4	Endocrine	£ 186,239.98	64	£ 2,916.06	12	0.93%	11	12	10	3
7	Neurological	£ 377,639.63	81	£ 4,677.53	6	0.44%	19	6	19	18
17	Genito-urinary	£ 548,134.04	7	£ 78,439.80	43	3.29%	5	4	11	6
16	Trauma & injuries*	£ 516,775.76	0	N/A	52	3.98%	3	7	6	8
18+19	Maternity & neonates*	£ 481,545.51	0	£ 7,526,403.52	32	2.42%	7	2	5	4
3	Disorders of Blood	£ 195,852.54	42	£ 4,703.82	9	0.67%	15	20	18	22
5	Mental Health	£ 1,187,618.17	137	£ 8,673.25	5	0.42%	20	15	20	12
6	Learning Disability	£ 157,547.24	2	£ 69,200.60	22	1.66%	9	5	7	10
8	Problems of Vision	£ 239,937.18	11	£ 21,838.83	10	0.77%	13	16	15	17
9	Problems of Hearing	£ 36,036.45	13	£ 2,675.78	8	0.60%	17	17	13	20
12	Dental problems	£ 229,875.99	24	£ 9,432.19	5	0.41%	21	11	14	14
14	Skin	£ 169,970.46	4	£ 46,661.01	8	0.64%	16	14	16	16
15	Musculo skeletal	£ 526,833.06	65	£ 8,159.61	2	0.15%	22	22	22	21
20	Poisoning and AE	£ 186,440.01	4	£ 49,191.19	6	0.48%	18	21	17	15
21	Healthy Individuals	£ 100,068.37	0	£ 214,734.17	19	1.41%	10	13	9	5
22	Social Care Needs	£ 270,712.47	0	N/A	41	3.11%	6	10	3	7
23	Other	£ 689,140.42	0	N/A	24	1.81%	8	3	4	9
Total:			1,314							

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) 2006/07	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09
2 Cancer	£ 999,160.83	34	3	-0.20%	16	15	14	14
10 Circulatory	£ 1,383,957.98	194	91	-6.96%	3	4	3	5
11 Respiratory	£ 642,465.45	12	448	-34.14%	1	1	1	1
13 Gastro-intestinal	£ 659,566.93	24	42	-3.23%	7	6	5	6
1 Infectious diseases	£ 214,481.53	2	9	-0.70%	12	11	10	10
4 Endocrine	£ 186,239.98	3	60	-4.60%	6	3	4	4
7 Neurological	£ 377,639.63	4	77	-5.87%	4	5	7	3
17 Genito-urinary	£ 548,134.04	1	6	-0.42%	13	13	11	18
16 Trauma & injuries*	£ 516,775.76	0	0	0.00%	-	-	-	-
18+19 Maternity & neonates*	£ 481,545.51	0	0	0.00%	19	19	19	19
3 Disorders of Blood	£ 195,852.54	2	39	-3.17%	8	8	8	9
5 Mental Health	£ 1,187,618.17	12	125	-10.42%	2	2	2	2
6 Learning Disability	£ 157,547.24	0	2	-0.17%	17	17	17	15
8 Problems of Vision	£ 239,937.18	0	11	-0.84%	11	12	12	12
9 Problems of Hearing	£ 36,036.45	0	13	-1.03%	10	9	9	8
12 Dental problems	£ 229,875.99	0	24	-1.86%	9	10	13	11
14 Skin	£ 169,970.46	1	2	-0.28%	15	14	16	13
15 Musculo skeletal	£ 526,833.06	3	61	-4.92%	5	7	6	7
20 Poisoning and AE	£ 186,440.01	1	3	-0.29%	14	16	15	16
21 Healthy Individuals	£ 100,068.37	0	0	-0.04%	18	18	18	17
22 Social Care Needs	£ 270,712.47	0	0	0.00%	-	-	-	-
23 Other	£ 689,140.42	0	0	0.00%	-	-	-	-
Total:		295	1,019					
Total change in QALY death + QALY alive			1,314					

Appendix 1: Outline of data update, estimation strategy, and results for outcome and expenditure models for 2005/06

Starting point: the 2006/07 specification

20. Identify the preferred specification for the outcome and expenditure equation for each programme budget category (PBC) for 2006/07. The outcome and expenditure elasticities generated by these specifications (when estimated at LA-level) are shown in Table A1.

Re-estimate the 2006/07 specifications using updated data

21. The 2006/07 specifications were derived using a combination PCT-level data mapped to LA-level and direct LA-level data. Backdate PCT-level data to 2005/06 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 2006/07 to 2005/06
- the raw population, unified weighted population, and MFF estimates used and implied by the resource allocations for 2005/06
- 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 (where possible).

Note that the PB data for 2005/06 was originally generated for the then 303 PCTs. This has been converted to the new 152 (since October 2006) PCT boundaries by the DH.

22. Obtain LA-level statistics for those variables that are reported at this unit of analysis. This will involve backdating LA-level data for 2006/07 to 2005/06. This will include backdating :

- mortality data for 2006/07/08 with data for 2005/06/07
- census-based variables for 2006 with data for 2005 (by appropriate interpolation between 2001 and 2011).

Complications: (i) no data for CKD prevalence for 2005/6 and 2006/7 so we use 2007/8 as a proxy for both years; (ii) prevalence rates for diabetes and epilepsy for 2005/6 are available by PCT but these rates are for the set of PCTs prior to the re-organisation in October 2006 (n=303). Without a mapper for this re-organisation, we use the prevalence rates for 2006/7 as proxies for the rates in 2005/6; (iii) a similar issue affects the IMD2007 and we have persevered with this here rather than investigating the IMD2004 (remember the IMD2004 uses data from 1997 to 2003); (iv) there were some relatively small boundary changes for local government in April 2009. Hitherto, our LA-level analysis has used this post-April 2009 geography. We persevere with this geography by adjusting the reported pre-April 2009 mortality rates so that they relate to the post-2009 boundaries as closely as possible.

More precisely, the re-organisation of local government created nine new unitary authorities (UAs). Five of these were created from existing county councils and their district councils. The remaining four new UAs were created by splitting Cheshire and Bedfordshire into two each along existing

district council boundaries. The nine unitary authorities are, therefore, all aggregates of existing local authorities. Further details of the re-organisation are shown below:

- Bedford UA was formed from Bedford District Council.
- Central Bedfordshire UA was formed from Mid Beds and South Beds District Councils.
- Cheshire East UA was formed from Congleton, Crewe & Nantwich and Macclesfield District Councils.
- Cheshire West and Chester UA was formed from Chester, Ellesmere Port and Vale Royal District Councils.
- Cornwall UA was formed from the Caradon, Carrick, Kerrier, North Cornwall, Penwith and Restormel District Councils (i.e., equals Cornwall county council except the Isles of Scilly).
- County Durham UA was formed from Chester-le-Street, Derwentside, Durham, Easington, Sedgfield, Teesdale and Wear Valley District Councils (i.e., Durham county council).
- Northumberland UA was formed from Alnwick, Berwick-upon-Tweed, Blyth Valley, Castle Morpeth, Tynedale and Wansbeck District Councils (i.e., Northumberland county council).
- Shropshire UA was formed from Bridgnorth, North Shropshire, Oswestry, Shrewsbury and South Shropshire District Councils (i.e., Shropshire county council).
- Wiltshire UA was formed from Kennet, North Wiltshire, Salisbury and West Wiltshire District Councils (i.e., Wiltshire county council).

The transition of Bedford from a district council (DC) to a UA poses no problems for us as mortality data for all district councils are routinely reported by the HSCIC. Thus we can backdate our UA-level data using DC data.

There is an issue with Bedfordshire UA and the two Cheshire UAs. How do we combine the mortality rates for the two or three component DCs to reflect the post-2009 UA boundaries? Population estimates for these DCs are readily available for 2000 (latest available from the NOMIS website) so we used these as weights so that we could combine the DC mortality rates to form the estimated UA mortality rates. Ideally, of course, we would use mortality and population data by age group and year for each of these DCs for each of the study periods to form the relevant UA data. But this would be a considerable undertaking (even if we could get the data) and it is not obvious that such an exercise would involve a sensible use of project resources (not least because only three UAs are affected).

Finally, there is a very slight discontinuity with the Cornwall data. We use the Cornwall county council mortality data for pre-2009 as a proxy for Cornwall UA data. The difference here is that the UA (population in 2000 is 495,400) excludes the Isles of Scilly (population 2,100) but the County Council includes it.

Estimation strategy for 2005/06: same as for 2006/07

23. Having backdated all data, use the preferred specification for 2006/07 to re-estimate each outcome and expenditure equation for 2005/06.
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 2006/07 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 2006/07 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 2006/07 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 2005/06: elasticities from preferred specifications

31. The estimation strategy outlined above generated the outcome and expenditure elasticities for 2005/06 shown in Table A1.

Results for 2005/06: 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 2005/06: estimation path to preferred specifications

33. The full estimation path for each result (starting with the re-estimation of the 2006/07 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 2005/06, 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	105***	A	-0.432	--	1205***	--								
2	Cancers and tumours	-0.345***	--	0.502**	A	-0.287***	--	0.784**	--	-0.273***	--	1626***	A	-0.239***	A	1219***	--	-0.159*	A	1592***	A								
3	Diseases of the blood	n/a		1060***	B	n/a		0.995***	--	n/a		1374***	--	n/a		1037***	--	n/a		1486***	--								
4	Endocrine, nutritional, metabolic	-1075**	A	0.708***	--	-1607**	--	0.498***	A	-1491	D	0.455***	--	-1464	A	0.630***	A	-1035	--	0.663***	--								
5	Mental health disorders	n/a		0.899***	--	n/a		0.995***	--	n/a		1103***	--	n/a		1143***	--	n/a		0.991***	--								
6	Learning disability	n/a		0.647**	B	n/a		0.329	--	n/a		0.386	--	n/a		0.410	B	n/a		0.449*	D								
7	Neurological problems	-1357	C	0.850***	--	-0.304	C	0.897***	--	-0.237*	B	0.733***	A	-0.869*	D	0.382*	A	-0.325	A	1220***	--								
8	Vision problems	n/a		0.934***	A	n/a		0.701***	--	n/a		1106***	C	n/a		0.931***	--	n/a		1127***	--								
9	Hearing problems	n/a		1273***	C	n/a		1637***	--	n/a		0.951*	A	n/a		0.989**	--	n/a		0.762**	--								
10	Circulatory problems	-1842***	--	0.494*	--	-1384***	--	1784***	A	-1315***	A	1614***	--	-1404***	--	1578***	--	-1637***	A	1477***	--								
11	Respiratory problems	-2.103***	B	0.576***	--	-1671***	--	0.752**	--	-1564***	A	1555***	A	-2.281***	--	1287***	--	-2.217***	A	1225***	A								
12	Dental problems	n/a		0.765***	B	n/a		0.428**	B	n/a		0.420***	D	n/a		0.835**	C	n/a		See text	n/a								
13	Gastro-intestinal problems	-1989*	A	0.387*	--	-1146**	A	0.520*	--	-0.837**	--	1490***	A	-1255**	--	1014***	A	-1014*	--	1076***	--								
14	Skin problems	n/a		0.890***	D	n/a		0.907***	--	n/a		0.787***	--	n/a		0.701***	A	n/a		0.840***	A								
15	Musculo-skeletal problems	n/a		0.295	B	n/a		0.738***	C	n/a		0.733***	--	n/a		0.628*	A	n/a		0.935***	--								
16	Trauma and injuries	0	n/a	1090***	--	0	n/a	1344***	--	-0.638	n/a	1328***	--	0	n/a	0.705***	--	Tbc		0.897***	A								
17	Genito-urinary problems	-2.997	B	0.878***	--	-0.024	C	0.733***	--	-1977	C	1015***	A	-0.588	D	0.988***	A	-0.869*	A	1079***	--								
18	Maternity and reproductive health	-0.166*	B	0.653***	--	-0.030	A	0.963***	--	-0.057	--	0.563**	--	-0.085	C	0.614**	--	-0.056	B	0.865***	--								
19	Neonates																												
20	Poisoning and adverse events	n/a		0.658**	--	n/a		2.102***	--	n/a		1674***	A	n/a		1107***	--	n/a		1735***	--								
21	Healthy individuals	n/a		1246**	--	n/a		1049	--	n/a		1296**	C	n/a		0.709	B	n/a		0.507	B								
22	Social care needs	n/a		0.844	B	n/a		1192*	--	n/a		1669**	C	n/a		1702***	--	n/a		1069*	--								
23	Other (includes GMS/FMS)	n/a		0.564***	B	n/a		0.338***	--	n/a		0.553***	--	n/a		0.447***	A	n/a		0.532***	--								

Notes: (i) see pp3-4 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 2006/07 specification using updated data generates an acceptable result, both statistically and in line with priors (see Table A4 and Table A6).

35. Expenditure: Re-estimation of the 2006/07 specification using updated data generates a reasonable result (see Table A5 and A7). [Apropos the reset test statistic, we did try investigating whether an additional regressor wanted to enter the specification but nothing proved successful.]

Cancer and tumours

36. Outcome: Re-estimation of the 2006/07 specification with updated data reveals an OK result except that expenditure is not significant and the instrument set is bordering on being slightly weak (Table A6). If we drop the 'need squared' term and replace one of the instruments with another (replace IMD with 'working in agriculture') then we obtain a more acceptable result (see Table A4 and Table A6).

37. Expenditure: Re-estimation of the 2006/07 specification reveals a slightly invalid instrument set (p -value=0.0718) but this can be remedied by dropping one instrument (unpaid carers) and adding a regressor (see Table A5 and Table A7). [Note that if unpaid carers is retained as an instrument in the latest specification then this pair passes the instrument validity test.]

Blood disorders

38. Expenditure: Re-estimation of the 2006/07 specification generates an acceptable result (see Table A5 and Table A7).

Endocrine, nutritional and metabolic

39. Outcome: Re-estimation of the 2006/07 specification using updated data generates an acceptable result (see Table A4 and Table A6). [Note that if we use OLS then the coefficient on expenditure falls from -1.035 to -0.150. Retain IV even though p -value is 0.333].

40. Expenditure: The 2006/07 specification generates an acceptable result (Table A5 and Table A7).

Mental health disorders

41. Expenditure: The 2006/07 specification generates an acceptable result (Table A5 and Table A7).

Learning disability

42. Expenditure: The 2006/07 specification generates a slightly poor result as the coefficient on the budget term is very small (0.158) and insignificant (Table A7). Excluding those LAs with expenditure outside the 5th and 95th percentiles improves things in some ways (eg the coefficient on budget increases) but not others (eg this specification fails the reset test). Re-derivation does not help much (Table A7) so we returned to the 2006/7 specification, dropped the insignificant regressors, and then checked to see which, if any, further regressor wanted to enter the specification. This approach generated a reasonable result (Table A5 and A7).

Neurological problems

43. Outcome: The 2006/07 specification (excluding those LAs with expenditure per head outside the 10th and 90th percentiles) generates a poor result in that it fails the reset test (see Table A6). Re-estimating this specification but only excluding those LAs with expenditure per head outside the 5th and 95th percentiles offers little improvement (Table A6). However, if we add the square of one of the regressors and drop the least significant instrument then this specification offers a more reasonable result (Table A4 and A6).

44. Expenditure: The 2006/07 specification generates the acceptable result shown in Table A5 and Table A7.

Problems of vision

45. Expenditure: The 2006/07 specification generates an acceptable result (Table A5 and Table A7).

Problems of hearing

46. Expenditure: The 2006/07 specification generates an acceptable result (Table A5 and Table A7).

Circulatory problems

47. Outcome: The 2006/07 specification fails the reset test (Table A6) but the addition of an extra regressor (permanently sick) resolves this issue (Table A6). Re-estimation without the now insignificant 'professional occupations' variable generates the result shown in Table A4 and A6.

48. Expenditure: The 2006/07 specification generates an acceptable result (Table A5 and Table A7).

Respiratory problems

49. Outcome: The 2006/07 specification reveals a weak instrument set (Table A6). Re-estimation without the insignificant 'permanently sick squared' variable does not resolve this issue (Table A6) but the addition of 'need squared' overcomes the previously failed reset test, and re-estimation without the 'permanently sick' variable overcomes the weak instrument issue (Table A4 and Table A6).

50. Expenditure: The 2006/07 specification reveals an invalid instrument set (Table A7). Re-estimation without the unpaid carers instrument generates a poor result ('other need' is neither endogenous nor significant) but re-estimation without the other instrument ('lone pensioners') generates an acceptable (Table A5 and Table A7).

Dental problems

51. Expenditure: The 2006/07 specification generates a poor result with a significant positive coefficient on 'other need' and a failed reset test (see 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 of this re-derived specification with sample restrictions (excluding LAs outside the 5th and 95th percentiles) offers no improvement (Table A7). Re-estimation of both of these specifications using OLS still generates a significant positive coefficient on 'other need' (see Table A7 for the OLS version with sample restrictions).

In the absence of a preferred specification, we might want to impute the value for the coefficient on budget using, say, either last year's value or the average of all coefficients on budget over the estimation period.

Gastro-intestinal problems

52. Outcome: The 2006/07 specification produces an acceptable result (see Table A4 and Table A6). [Note that if we add a second instrument (eg IMD2007) then the resulting specification passes all tests and the coefficient on expenditure is -1.178**.]

53. Expenditure: The 2006/07 specification generates an acceptable result (Table A5 and Table A7) even though the 'other need' variable is only endogenous at the 20% level. [Note that if we add a second instrument (eg lone parents) then the resulting specification passes all tests and the coefficient on budget is 1.060***.]

Skin problems

54. Expenditure: The 2006/07 specification generates an acceptable result but the 'professional occupations' variable is insignificant (Table A7). Using the usual pool of available needs indicators, we found that the 'no qualifications' variable is significant if added to the specification, and this result (without the insignificant 'professional occupations' variable) is shown in Tables A5 and A7.

Musculo-Skeletal system

55. Expenditure: The 2006/07 specification generates an acceptable (see Table A5 and Table A7).

Trauma and injuries

56. Outcome: Awaiting femur fracture and skull fracture SMRs from HSCIC (now NHS Digital).

57. Expenditure: The 2006/07 specification fails the reset test (Table A7) but re-estimation with the addition of the 'need' variable generates an OK result (Table A5 and Table A7).

Genito-urinary system

58. Outcome: The 2006/07 specification generates an OK result but expenditure is insignificant (see Table A6). Using the usual pool of available socio-economic indicators, we checked whether any of these variables wanted to be included in the specification. We found that the addition of the 'owner occupier' variable resulted in a significant coefficient on the expenditure variable (see Table A4 and A6).

59. Expenditure: The 2006/07 specification generates an acceptable result (Table A5 and Table A7).

Maternity/Neonates

60. Outcome: The 2006/07 specification generates a poor result; the instrument set is not valid and it fails the reset test (Table A6). The re-derived specification suggests that 'other need' is not significant and re-estimation using OLS generates the result shown in Table A4 and Table A6.

61. Expenditure: The 2006/07 specification generates an acceptable result (see Table A5 and Table A7).

Poisoning

62. Expenditure: The 2006/07 specification generates an acceptable result (Table A5 and Table A7).

Healthy Individuals

63. Expenditure: The 2006/07 specification generates a poor result: 'other need' has a significant positive coefficient and all other regressors are insignificant (Table A7). Re-derivation generates a more acceptable result but 'other need' is not endogenous (Table A5 and Table A7). OLS estimation of the re-derived specification generates a significant positive coefficient on 'other need' (Table A7) so the IV specification is our preferred one.

Social Care

64. Expenditure: The 2006/07 specification generates an OK result but there is little evidence to suggest that the 'other need' variable is endogenous (Table A5 and A7). However, re-estimation using OLS generates insignificant coefficients on both budget and 'other need' (Table A7) so we prefer the IV specification. [Note that the sample restriction to LAs with expenditure per head of between £15 and £75 is the same as that employed for 2006/07. This is necessary because there is a large number of 'outliers'].

GMS/PMS

65. Expenditure: The 2006/07 specification generates an acceptable result (see Table A5 and Table A7).

All PBCs: Comparing specifications for 2005/06 and 2006/07

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

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	n=1		
Expenditure equation	(maximum n=22)	n=11	n=12	n=12	n=12		

APPENDIX

Part B Preferred specifications for outcome and expenditure models for 2005/06

In this section, Tables A4 and A5 provide details of our preferred specification for each outcome and expenditure model by PBC for 2005/06.

Table A4 Preferred outcome specifications for 2005/06

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	PBC 1	PBC 2	PBC 4	PBC 7	PBC 10	PBC 11	PBC 13	PBC 17	PBC 1819
	infectious	cancer	endocrine	neurological	circulatory	respiratory	gastro	genito-	mat/neonates
	2005/6 spend	2005/6 spend	2005/6 spend	2005/6 spend	2005/6 spend	2005/6 spend	2005/6 spend	2005/6 spend	2005/6 spend
	SYLLR 2005/6/7	SYLLR 2005/6/7	SYLLR 2005/6/7	SYLLR 2005/6/7	SYLLR 2005/6/7	SYLLR 2005/6/7	SYLLR 2005/6/7	SYLLR 2005/6/7	2005/6/7
	outcome model	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 n/a	instrument spend
	weighted	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	OLS	OLS
	GMM2S	GMM2S	GMM2S	GMM2S	GMM2S	GMM2S	GMM2S		
	LA-level	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 mortality
	actual census 05	actual census 05	actual census 05	actual census 05	actual census 05	actual census 05	actual census 05	actual census 05	actual census 05
VARIABLES	6/7 specification	06/07 revised	06/07 specification	6/7 revised+	06/07 revised+	06/07 revised	06/07 specification	6/7 revised 5/95%	rederived OLS
ILAg1_56	-0.432 [0.377]								
ILAhivneedph	0.478*** [0.142]								
ILAhivneedph2	0.085 [0.084]								
ILAIMD_2007exexpobook	0.372*** [0.097]		0.629*** [0.149]	0.223** [0.102]					0.158** [0.070]
ILAg2_56OHP		-0.159* [0.086]							
ILANeedCARAN56		0.758*** [0.078]			0.901** [0.381]	4.676*** [1.026]	3.416*** [0.587]		
ILAg4_56OHP			-1.035 [1.002]						
ILAdiaprev0506			1.023*** [0.371]						
ILAg7_56OHP				-0.325 [0.434]					
LPOPPUCAR05				10.101 [8.381]				-2.979** [1.486]	
LPOPPUCAR05SQ				1.971 [1.781]					
ILAg10_56netpopheadOHP					-1.637*** [0.354]				

LPERMSICK05					0.737***				
					[0.135]				
ILAg11_56OHP						-2.217***			
						[0.827]			
ILANeedCARAN562						1.629			
						[1.293]			
ILAg13_56netpopheadOHP							-1.014*		
							[0.523]		
ILAg17_56netpopheadOHP								-0.869*	
								[0.465]	
LNQUAL17405								2.533***	0.719***
								[0.711]	[0.146]
LOWNOCC05								-0.849	
								[0.576]	
LWHITEEG05								-0.822	
								[0.515]	
ILAg1819_56OHP									-0.056
									[0.089]
LLONEPENH05									-0.404*
									[0.233]
LBORNEXEU05									0.078*
									[0.043]
Constant	2.241**	5.730***	6.349	14.837	14.726***	12.403***	7.559***	-0.941	1.289**
	[0.925]	[0.381]	[4.263]	[10.345]	[1.927]	[3.496]	[2.294]	[2.829]	[0.608]
Observations	149	151	136	136	151	151	151	136	151
R-squared								0.228	0.407
Endogeneity test statistic	1.680	3.078	0.937	1.490	28.751	20.370	6.411		
Endogeneity p-value	0.195	0.079	0.333	0.222	0.000	0.000	0.011		
Kleibergen-Paap LM test statistic	12.475	18.668	8.162	20.976	14.371	7.453	16.180		
Kleibergen-Paap p-value	0.000	0.000	0.004	0.000	0.001	0.006	0.000		
Kleibergen-Paap F statistic	19.089	15.860	9.794	15.137	14.185	12.876	29.084		
Pesaran-Taylor reset statistic	0.046	0.912	0.194	0.079	0.330	0.784	0.510		
Pesaran-Taylor p-value	0.830	0.340	0.660	0.779	0.566	0.376	0.475		
Hansen-Sargan test statistic		0.052		0.028		0.292			
Hansen-Sargan p-value		0.820		0.868		0.589			
Ramsey reset F statistic								0.538	0.003
Probability > F								0.657	1.000

Robust standard errors in brackets

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

Table A5 Preferred expenditure specifications for 2005/06

	(1) PBC 1 infectious 2005/6 spend SYLLR 2005/6/7 spend model instrument n/a weighted OLS	(2) PBC 2 cancer 2005/6 spend SYLLR 2005/6/7 spend model instrument o/need weighted IV second stage GMM2S	(3) PBC 3 blood 2005/6 spend SYLLR 2005/6/7 spend model instrument n/a weighted OLS	(4) PBC 4 endocrine 2005/6 spend SYLLR 2005/6/7 spend model instrument n/a weighted OLS	(5) PBC 5 mental health 2005/6 spend SYLLR 2005/6/7 spend model instrument n/a weighted OLS	(6) PBC 6 LDisability 2005/06 spend SYLLR 2005/06/07 spend model instrument n/a weighted OLS	(7) PBC 7 neurological 2005/06 spend SYLLR 2005/06/07 spend model instrument n/a weighted OLS	(8) PBC 8 vision 2005/6 spend SYLLR 2005/6/7 spend model instrument o/need weighted IV second stage GMM2S	(9) PBC 9 hearing 2005/6 spend SYLLR 2005/6/7 spend model instrument n/a weighted OLS	(10) PBC 10 circulatory 2005/6 spend SYLLR 2005/6/7 spend model instrument o/need weighted IV second stage GMM2S
VARIABLES	LA-level actual mortality actual census 05 06/07 specification	LA-level actual mortality actual census 06 06/07 revised	LA-level actual mortality actual census 05 06/07 specification	LA-level actual mortality actual census 05 06/07 specification	LA-level actual mortality actual census 05 06/07 specification	LA-level actual mortality actual census 05 6/7 revised	LA-level actual mortality actual census 05 6/7 specification	LA-level actual mortality actual census 05 06/07 specification	LA-level actual mortality actual census 05 06/07 specification	LA-level actual mortality actual census 05 06/07 specification
ILAgall_56netpopheadOHP	1.205*** [0.208]	1.592*** [0.282]	1.486*** [0.410]	0.663*** [0.126]	0.991*** [0.142]	0.449* [0.266]	1.220*** [0.239]	1.127*** [0.278]	0.762** [0.346]	1.477*** [0.206]
ILAhivneedph	0.374*** [0.025]									
ISYLLRacExlandP567	-0.410*** [0.154]									
ILAhivneedph2	0.174*** [0.022]									
ISYLLRacExCancer567		-1.358*** [0.440]								
LPROFOCCU05		-0.701*** [0.242]							-0.523*** [0.181]	
LOWNOCC05		-0.262 [0.249]								
ISYLLRallcause567			-0.978** [0.393]		-0.364*** [0.134]	-0.061 [0.195]		-0.890*** [0.263]	-0.189 [0.286]	
LLONEPARH05			0.727*** [0.198]							
LNQUAL17405				0.281*** [0.069]				0.643*** [0.104]		0.566*** [0.113]
ISYLLRacExDIA567				-0.060 [0.109]						
ILAmhneedindexpp					0.542*** [0.141]					
LPOPPUCAR05					-0.801*** [0.100]					
ILAneedCARAN562						1.844 [1.223]				
ILAEpiprev0506							0.330*** [0.089]			
ISYLLRacExEPI567							-0.446*** [0.161]			
ISYLLRacExCirc567										-1.190*** [0.256]
Constant	-3.136***	-0.270	0.095	-0.417	-1.681	0.915	-0.722	1.527	-3.186*	1.952*

	[1.008]	[1.991]	[2.383]	[0.844]	[1.496]	[1.474]	[1.304]	[0.987]	[1.801]	[1.147]
Observations	149	151	151	151	151	137	151	151	151	151
R-squared	0.780		0.282	0.382	0.690	0.058	0.312		0.240	
Ramsey reset F statistic	2.114		0.768	0.813	0.895	1.344	1.913		1.140	
Probability > F	0.101		0.514	0.489	0.445	0.263	0.130		0.335	
Endogeneity test statistic		8.069						4.617		21.249
Endogeneity p-value		0.005						0.032		0.000
Kleibergen-Paap LM test statistic		14.048						38.585		25.420
Kleibergen-Paap p-value		0.000						0.000		0.000
Kleibergen-Paap F statistic		15.505						48.814		22.302
Pesaran-Taylor reset statistic		0.048						0.008		0.084
Pesaran-Taylor p-value		0.826						0.928		0.772
Hansen-Sargan test statistic								0.117		0.060
Hansen-Sargan p-value								0.733		0.806

Robust standard errors in brackets

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

Table A5 continued Preferred expenditure specifications for 2005/06

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PBC 11	PBC 13	PBC 14	PBC 15	PBC 16	PBC 17	PBC 1819	PBC 20
	respiratory	gastro	skin problems	musculo-skeletal	trauma	genito-	mat/neonates	poisoning
	2005/6 spend	2005/6 spend	2005/06 spend	2005/06 spend	2005/6 spend	2005/6 spend	2005/06 spend	2005/6 spend
	SYLLR 2005/6/7	SYLLR 2005/6/7	SYLLR 2005/6/7	SYLLR 2005/6/7	SYLLR 2005/6/7	SYLLR 2005/6/7	infant mort rate	SYLLR 2005/6/7
	spend model	spend model	spend model	spend model	spend model	spend model	2005/06/07	spend model
	instrument o/need	instrument o/need	instrument n/a	instrument n/a	instrument n/a	instrument n/a	o/need exogenous	instrument o/need
	weighted	weighted	weighted	weighted	weighted	weighted	weighted	weighted
	IV second stage	IV second stage	OLS	OLS	OLS	OLS	OLS	IV second stage
	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 05	actual census 05	actual census 05	actual census 05	actual census 05	actual census 05	actual census 05	actual census 05
VARIABLES	06/07 revised	06/07 specification	06/07 revised	06/07 specification	06/07 revised	06/07 specification	06/07 specification	06/07 specification
ISYLLRacExResp567	-0.381*							
	[0.207]							
ILAgall_56netpopheadOHP	1.225***	1.076***	0.840***	0.935***	0.897***	1.079***	0.865***	1.735***
	[0.191]	[0.154]	[0.190]	[0.205]	[0.250]	[0.264]	[0.157]	[0.264]
LNQUAL17405	0.414***	0.416***	0.175**					0.449***
	[0.075]	[0.059]	[0.079]					[0.136]
ISYLLRacExGast567		-0.413**						
		[0.199]						
ISYLLRallcause567			0.033	0.038	-0.170		-0.127	-1.235***
			[0.153]	[0.156]	[0.145]		[0.132]	[0.288]
LPC74LTUN05				-0.309***		0.183**		
				[0.069]		[0.081]		
LPROFOCCU05				-0.418***				
				[0.092]				
LWORKAGRI05					0.047***			
					[0.013]			
ILAneedCARAN56					0.376			
					[0.315]			
ISYLLRacExrenal567						-0.326*		
						[0.169]		
ILAmatneedindexpp							0.734***	
							[0.119]	
Constant	-1.704**	-0.274	-2.722***	-4.523***	-0.836	-0.755	-1.145	-1.676
	[0.779]	[0.721]	[0.924]	[1.593]	[2.201]	[2.014]	[0.869]	[1.299]
Observations	151	151	151	151	151	151	151	151
Endogeneity test statistic	4.593	1.596						15.227
Endogeneity p-value	0.032	0.206						0.000
Kleibergen-Paap LM test statistic	27.275	34.219						33.883
Kleibergen-Paap p-value	0.000	0.000						0.000
Kleibergen-Paap F statistic	57.822	107.256						40.297
Pesaran-Taylor reset statistic	0.002	1.800						0.260
Pesaran-Taylor p-value	0.964	0.180						0.610
Hansen-Sargan test statistic								1.785

Hansen-Sargan p-value						0.182
R-squared	0.412	0.395	0.464	0.441	0.497	
Ramsey reset F statistic	1.493	2.060	1.611	1.397	0.840	
Probability > F	0.219	0.108	0.190	0.246	0.474	

Robust standard errors in brackets

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

Table A5 continued Preferred expenditure specifications for 2005/06

	(1)	(2)	(3)
	PBC 21	PBC 22	PBC 23a
	HI	social care	GMS
	2005/6 spend	2005/6 spend	2005/6 spend
	SYLLR 2005/6/7	SYLLR 2005/6/7	SYLLR 2005/6/7
	spend model	spend model	spend model
	instrument o/need	instrument o/need	instrument n/a
	weighted	weighted	weighted
	IV second stage	IV second stage	OLS
	GMM2S	GMM2S	
	LA-level	LA-level	LA-level
	actual mortality	actual mortality	actual mortality
	actual census 05	actual census 05	actual census 05
VARIABLES	re-derived	06/07 specification	06/07 specification
ISYLLRallcause567	0.413	-0.893*	-0.102*
	[0.342]	[0.532]	[0.052]
ILAgall_56netpopheadOHP	0.507	1.069*	0.532***
	[0.371]	[0.614]	[0.070]
LPOPPUCAR05	-0.864**		
	[0.381]		
LBORNEXEU05	-0.151**		
	[0.067]		
LWORKAGRI05	-0.090*		0.035***
	[0.051]		[0.010]
LWHITEEG05			-0.194***
			[0.045]
Constant	-5.832***	1.173	1.929***
	[2.224]	[2.588]	[0.347]
Observations	151	116	147
R-squared			0.391
Endogeneity test statistic	0.304	0.599	
Endogeneity p-value	0.581	0.439	
Hansen-Sargan test statistic	1.658	3.943	
Hansen-Sargan p-value	0.646	0.268	
Kleibergen-Paap LM test statistic	36.779	33.298	
Kleibergen-Paap p-value	0.000	0.000	
Kleibergen-Paap F statistic	50.792	38.220	
Pesaran-Taylor reset statistic	0.527	0.000	
Pesaran-Taylor p-value	0.468	0.984	
Ramsey reset F statistic			0.691
Probability > F			0.559

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 2005/06

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 2005/06. For each PBC, we first estimate the model for 2005/06 using our preferred specification for 2006/07. 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 2005/06 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 2005/06

	(1) PBC 1 infectious 2005/6 spend SYLLR 2005/6/7 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 05 6/7 specification	(2) PBC 2 cancer 2005/6 spend SYLLR 2005/6/7 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 05 6/7 specification	(3) PBC 2 cancer 2005/6 spend SYLLR 2005/6/7 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 05 06/07 revised	(4) PBC 4 endocrine 2005/6 spend SYLLR 2005/6/7 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 05 6/7 specification	(5) PBC 7 neurological 2005/6 spend SYLLR 2005/6/7 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 05 6/7 specification	(6) PBC 7 neurological 2005/6 spend SYLLR 2005/6/7 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 05 6/7 revised	(7) PBC 7 neurological 2005/6 spend SYLLR 2005/6/7 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 05 6/7 revised+	(8) PBC 10 circulatory 2005/6 spend SYLLR 2005/6/7 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 05 6/7 specification	(9) PBC 10 circulatory 2005/6 spend SYLLR 2005/6/7 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 05 06/07 revised	(10) PBC 10 circulatory 2005/6 spend SYLLR 2005/6/7 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 05 06/07 revised+
VARIABLES										
ILAg1_56	-0.432 [0.377]									
ILAhivneedph	0.478*** [0.142]									
ILAhivneedph2	0.085 [0.084]									
ILAimd_2007exexpobook	0.372*** [0.097]			0.629*** [0.149]	0.219** [0.105]	0.235** [0.094]	0.223** [0.102]			
ILAg2_56OHP		-0.126 [0.091]	-0.159* [0.086]							
ILAneedCARAN56		0.726*** [0.075]	0.758*** [0.078]					2.343*** [0.370]	0.987** [0.391]	0.901** [0.381]
ILAneedCARAN562		0.860*** [0.238]								
ILAg4_56OHP				-1.035						

ILAdiaprev0506				[1.002] 1.023*** [0.371]						
ILAg7_56OHP					-0.148 [0.491]	-0.144 [0.403]	-0.325 [0.434]			
LPOPPUCAR05					1.025*** [0.302]	0.674** [0.308]	10.101 [8.381]			
LPOPPUCAR05SQ							1.971 [1.781]			
ILAg10_56netpopheadOHP								-1.720*** [0.335]	-1.764*** [0.324]	-1.637*** [0.354]
LPROFOCCU05								-0.457*** [0.151]	-0.154 [0.189]	
LPERMSICK05									0.674*** [0.182]	0.737*** [0.135]
Constant	2.241** [0.925]	5.572*** [0.403]	5.730*** [0.381]	6.349 [4.263]	3.757* [1.987]	2.905* [1.720]	14.837 [10.345]	12.274*** [1.647]	14.947*** [1.980]	14.726*** [1.927]
Observations	149	151	151	136	122	136	136	151	151	151
Endogeneity test statistic	1.680	1.512	3.078	0.937	0.439	0.850	1.490	31.549	35.260	28.751
Endogeneity p-value	0.195	0.219	0.079	0.333	0.507	0.357	0.222	0.000	0.000	0.000
Kleibergen-Paap LM test statistic	12.475	16.475	18.668	8.162	21.724	26.635	20.976	18.456	17.245	14.371
Kleibergen-Paap p-value	0.000	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.001
Kleibergen-Paap F statistic	19.089	10.063	15.860	9.794	10.444	12.320	15.137	18.479	18.003	14.185
Pesaran-Taylor reset statistic	0.046	0.004	0.912	0.194	2.950	3.674	0.079	4.530	0.009	0.330
Pesaran-Taylor p-value	0.830	0.950	0.340	0.660	0.086	0.055	0.779	0.033	0.926	0.566
Hansen-Sargan test statistic		2.610	0.052		0.145	0.430	0.028	0.934	0.571	0.292
Hansen-Sargan p-value		0.106	0.820		0.930	0.806	0.868	0.334	0.450	0.589

Robust standard errors in brackets

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

Table A6 continued Estimation path to preferred outcome specifications for 2005/06

	(1) PBC 11 respiratory 2005/6 spend	(2) PBC 11 respiratory 2005/6 spend	(3) PBC 11 respiratory 2005/6 spend	(4) PBC 13 gastro 2005/6 spend	(5) PBC 17 genito- 2005/6 spend	(6) PBC 17 genito- 2005/6 spend	(7) PBC 1819 mat/neonates 2005/6 spend infant mort rate 2005/6/7	(8) PBC 1819 mat/neonates 2005/6 spend Infant mort rate 2005/6/7	(9) PBC 1819 mat/neonates 2005/06 spend infant mort rate 2005/6/7
	SYLLR 2005/6/7 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 05	SYLLR 2005/6/7 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 05	SYLLR 2005/6/7 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 05	SYLLR 2005/6/7 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 05	SYLLR 2005/6/7 outcome model instrument n/a weighted OLS LA-level actual mortality actual census 05 6/7 specification 5/95%	SYLLR 2005/6/7 outcome model instrument n/a weighted OLS LA-level actual mortality actual census 05 6/7 revised 5/95%	outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 05 6/7 specification	outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 05 re-derived	outcome model spend exogenous weighted OLS LA-level actual mortality actual census 05 re-derived OLS
VARIABLES	06/07 specification	06/07 revised	06/07 revised	06/07 specification	5/95%	6/7 revised 5/95%	6/7 specification	re-derived	re-derived OLS
ILAg11_56netpopheadOHP	-6.665* [3.846]	-5.615* [2.911]							
ILAneedCARAN56	3.312* [1.803]	3.093** [1.479]	4.676*** [1.026]	3.416*** [0.587]			-0.196 [0.547]		
LPERMSICK05	6.000 [4.015]	2.181** [1.074]							
LPERMSICK05SQ	0.555 [0.485]								
ILAg11_56OHP			-2.217*** [0.827]						
ILAneedCARAN562			1.629 [1.293]						
ILAg13_56netpopheadOHP				-1.014* [0.523]					
ILAg17_56netpopheadOHP					-0.695 [0.467]	-0.869* [0.465]			
LNQUAL17405					2.840*** [0.640]	2.533*** [0.711]	0.715*** [0.147]		0.719*** [0.146]
LPOPPUCAR05					-3.922*** [1.182]	-2.979** [1.486]			
LWHITEEG05					-0.991* [0.531]	-0.822 [0.515]			
LOWNOCC05						-0.849 [0.576]			
ILAg1819_56OHP							-0.244 [0.265]	-0.014 [0.264]	-0.056 [0.089]
LBORNEXEU05							0.073 [0.045]	0.092** [0.040]	0.078* [0.043]
LHHNOCAR05							-0.506** [0.203]		
LPC74LTUN05							0.256 [0.157]		
ILAIMD_2007exexpobook							0.674*** [0.212]	0.160 [0.113]	0.158** [0.070]

LLONEPENH05								-0.280	-0.404*
Constant	44.410*	33.536**	12.403***	7.559***	-3.115	-0.941	0.811	[0.235]	[0.233]
	[23.502]	[15.425]	[3.496]	[2.294]	[2.283]	[2.829]	[1.902]	[0.783]	[0.608]
Observations	151	151	151	151	136	136	151	151	151
R-squared					0.223	0.228			0.407
Endogeneity test statistic	27.135	26.925	20.370	6.411			0.851	0.036	
Endogeneity p-value	0.000	0.000	0.000	0.011			0.356	0.849	
Kleibergen-Paap LM test statistic	2.693	3.355	7.453	16.180			20.873	16.499	
Kleibergen-Paap p-value	0.101	0.067	0.006	0.000			0.000	0.002	
Kleibergen-Paap F statistic	3.075	4.024	12.876	29.084			12.143	8.419	
Pesaran-Taylor reset statistic	0.027	6.929	0.784	0.510			5.162	0.001	
Pesaran-Taylor p-value	0.869	0.008	0.376	0.475			0.023	0.969	
Ramsey reset F statistic					0.424	0.538			0.003
Probability > F					0.736	0.657			1.000
Hansen-Sargan test statistic							4.203	4.839	
Hansen-Sargan p-value							0.040	0.184	

Robust standard errors in brackets

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

Table A7 Estimation path to preferred expenditure specifications for 2005/06

	(1) PBC 1 infectious 2005/6 spend SYLLR 2005/6/7 spend model instrument n/a weighted OLS LA-level actual mortality actual census 05 06/07 specification	(2) PBC 2 cancer 2005/6 spend SYLLR 2005/6/7 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 06 06/07 specification	(3) PBC 2 cancer 2005/6 spend SYLLR 2005/6/7 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 06 06/07 revised	(4) PBC 3 blood 2005/6 spend SYLLR 2005/6/7 spend model instrument n/a weighted OLS LA-level actual mortality actual census 05 06/07 specification	(5) PBC 4 endocrine 2005/6 spend SYLLR 2005/6/7 spend model instrument n/a weighted OLS LA-level actual mortality actual census 05 06/07 specification	(6) PBC 5 mental health 2005/6 spend SYLLR 2005/6/7 spend model instrument n/a weighted OLS LA-level actual mortality actual census 05 06/07 specification	(7) PBC 6 LDisability 2005/06 spend SYLLR 2005/06/07 spend model instrument n/a weighted OLS LA-level actual mortality actual census 05 6/7 specification	(8) PBC 6 LDisability 2005/06 spend SYLLR 2005/06/07 spend model instrument n/a weighted OLS LA-level actual mortality actual census 05 6/7 revised	(9) PBC 6 LDisability 2005/6 spend SYLLR 2005/6/7 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 05 re-derived	(10) PBC 6 LDisability 2005/06 spend SYLLR 2005/06/07 spend model instrument n/a weighted OLS LA-level actual mortality actual census 05 6/7 revised
ILAgall_56netpopheadOHP	1.205*** [0.208]	1.475*** [0.242]	1.592*** [0.282]	1.486*** [0.410]	0.663*** [0.126]	0.991*** [0.142]	0.158 [0.402]	0.449 [0.282]	0.108 [0.332]	0.449* [0.266]
ILAhivneedph	0.374*** [0.025]									
ISYLLRacExlandP567	-0.410*** [0.154]									
ILAhivneedph2	0.174*** [0.022]									
ISYLLRacExCancer567		-0.915*** [0.202]	-1.358*** [0.440]							
LPROFOCCU05		-0.477*** [0.109]	-0.701*** [0.242]				-0.382 [0.252]	-0.258 [0.227]		
LOWNOCC05			-0.262 [0.249]							
ISYLLRallcause567				-0.978** [0.393]		-0.364*** [0.134]	-0.103 [0.309]	-0.200 [0.280]	-0.198 [0.338]	-0.061 [0.195]
LLONEPARH05				0.727*** [0.198]						
LNQUAL17405					0.281*** [0.069]					
ISYLLRacExDIA567					-0.060 [0.109]					
ILAmhneedindexpp						0.542*** [0.141]				
LPOPPUCAR05						-0.801*** [0.100]				
LBORNEXEU05							0.160** [0.078]	0.067 [0.056]		
LWHITEEG05							0.664* [0.344]	0.210 [0.220]		
LPERMSICK05									0.209 [0.183]	
ILAneedCARAN562										1.844 [1.223]
Constant	-3.136***	-1.563	-0.270	0.095	-0.417	-1.681	3.335	1.677	4.863	0.915

	[1.008]	[1.093]	[1.991]	[2.383]	[0.844]	[1.496]	[2.418]	[1.620]	[3.770]	[1.474]
Observations	149	151	151	151	151	151	151	137	137	137
R-squared	0.780			0.282	0.382	0.690	0.039	0.057		0.058
Ramsey reset F statistic	2.114			0.768	0.813	0.895	0.236	2.427		1.344
Probability > F	0.101			0.514	0.489	0.445	0.871	0.068		0.263
Endogeneity test statistic		8.114	8.069						0.113	
Endogeneity p-value		0.004	0.005						0.737	
Hansen-Sargan test statistic		3.243							0.386	
Hansen-Sargan p-value		0.072							0.984	
Kleibergen-Paap LM test statistic		32.575	14.048						37.018	
Kleibergen-Paap p-value		0.000	0.000						0.000	
Kleibergen-Paap F statistic		33.127	15.505						28.413	
Pesaran-Taylor reset statistic		0.022	0.048						0.066	
Pesaran-Taylor p-value		0.882	0.826						0.798	

Robust standard errors in brackets

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

Table A7 continued Estimation path to preferred expenditure specifications for 2005/06

	(1) PBC 7 neurological 2005/06 spend SYLLR 2005/06/07 spend model instrument n/a weighted OLS LA-level actual mortality actual census 05 6/7 specification	(2) PBC 8 vision 2005/6 spend SYLLR 2005/6/7 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 05 06/07 specification	(3) PBC 9 hearing 2005/6 spend SYLLR 2005/6/7 spend model instrument n/a weighted OLS LA-level actual mortality actual census 05 06/07 specification	(4) PBC 10 circulatory 2005/6 spend SYLLR 2005/6/7 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 05 06/07 specification	(5) PBC 11 respiratory 2005/6 spend SYLLR 2005/6/7 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 05 06/07 specification	(6) PBC 11 respiratory 2005/6 spend SYLLR 2005/6/7 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 05 06/07 revised	(7) PBC 12 dental 2005/6 spend SYLLR 2005/6/7 spend model instrument n/a weighted OLS LA-level actual mortality actual census 05 6/7 specification	(8) PBC 12 dental 2005/6 spend SYLLR 2005/6/7 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 05 re-derived	(9) PBC 12 dental 2005/6 spend SYLLR 2005/6/7 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 05 re-derived+	(10) PBC 12 dental 2005/6 spend SYLLR 2005/6/7 spend model instrument n/a weighted OLS LA-level actual mortality actual census 05 re-derived++
ILAgall_56netpopheadOHP	1.220*** [0.239]	1.127*** [0.278]	0.762** [0.346]	1.477*** [0.206]	1.006*** [0.157]	1.225*** [0.191]	1.224** [0.571]	0.886 [0.580]	1.085* [0.604]	1.251** [0.484]
ILAepiprev0506	0.330*** [0.089]									
ISYLLRacExEPI567	-0.446*** [0.161]									
ISYLLRallcause567		-0.890*** [0.263]	-0.189 [0.286]				2.041*** [0.598]	2.606*** [0.739]	2.291*** [0.734]	1.900*** [0.458]
LNQUAL17405		0.643*** [0.104]		0.566*** [0.113]	0.354*** [0.070]	0.414*** [0.075]		-0.954** [0.425]	-1.074** [0.429]	-0.817** [0.342]
LPROFOCCU05			-0.523*** [0.181]							
ISYLLRacExCirc567				-1.190*** [0.256]						
ISYLLRacExResp567					-0.148 [0.176]	-0.381* [0.207]				
LPERMSICK05							0.080 [0.268]			
LLONEPARH05							-3.207 [2.599]			
LLONEPARH05SQ							-0.469 [0.484]			
LWHITEEG05							1.208*** [0.309]	0.654** [0.282]	0.795*** [0.262]	0.791*** [0.270]
LPOPPUCAR05								1.687*** [0.562]	1.616*** [0.599]	1.375** [0.585]
LWORKAGRI05								0.214*** [0.068]	0.159** [0.066]	0.139** [0.060]
Constant	-0.722 [1.304]	1.527 [0.987]	-3.186* [1.801]	1.952* [1.147]	-1.625** [0.755]	-1.704** [0.779]	-23.019*** [7.826]	-15.447*** [2.665]	-15.525*** [2.676]	-14.653*** [2.800]
Observations	151	151	151	151	151	151	151	151	137	137
R-squared	0.312		0.240				0.465			0.494
Ramsey reset F statistic	1.913		1.140				2.759			1.345
Probability > F	0.130		0.335				0.045			0.263

Endogeneity test statistic	4.617	21.249	1.099	4.593	0.070	0.323
Endogeneity p-value	0.032	0.000	0.295	0.032	0.791	0.570
Hansen-Sargan test statistic	0.117	0.060	5.417		2.931	1.472
Hansen-Sargan p-value	0.733	0.806	0.020		0.231	0.479
Kleibergen-Paap LM test statistic	38.585	25.420	32.269	27.275	31.972	27.683
Kleibergen-Paap p-value	0.000	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap F statistic	48.814	22.302	36.508	57.822	25.886	20.507
Pesaran-Taylor reset statistic	0.008	0.084	0.000	0.002	0.059	0.082
Pesaran-Taylor p-value	0.928	0.772	0.987	0.964	0.808	0.774

Robust standard errors in brackets

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

Table A7 continued Estimation path to preferred expenditure specifications for 2005/06

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	PBC 13	PBC 14	PBC 14	PBC 15	PBC 16	PBC 16	PBC 17	PBC 1819	PBC 20
	gastro	skin problems	skin problems	musculo-skeletal	trauma	trauma	genito-	mat/neonates	poisoning
	2005/6 spend	2005/06 spend	2005/06 spend	2005/06 spend	2005/6 spend	2005/6 spend	2005/6 spend	2005/06 spend	2005/6 spend
	SYLLR 2005/6/7	SYLLR 2005/6/7	SYLLR 2005/6/7	SYLLR 2005/6/7	SYLLR 2005/6/7	SYLLR 2005/6/7	SYLLR 2005/6/7	2005/06/07	SYLLR 2005/6/7
	spend model	spend model	spend model	spend model	spend model	spend model	spend model	spend model	spend model
	instrument o/need	instrument n/a	instrument n/a	instrument n/a	instrument n/a	instrument n/a	instrument n/a	o/need exogenous	instrument o/need
	weighted	weighted	weighted	weighted	weighted	weighted	weighted	weighted	weighted
	IV second stage	OLS	OLS	OLS	OLS	OLS	OLS	OLS	IV second stage
	GMM2S								GMM2S
	LA-level	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 mortality
	actual census 05	actual census 05	actual census 05	actual census 05	actual census 05	actual census 05	actual census 05	actual census 05	actual census 05
VARIABLES	06/07 specification	06/07 specification	06/07 revised	06/07 specification	06/07 specification	06/07 revised	06/07 specification	06/07 specification	06/07 specification
ISYLLRacExGast567	-0.413** [0.199]								
ILAgall_56netpopheadOHP	1.076*** [0.154]	0.825*** [0.187]	0.840*** [0.190]	0.935*** [0.205]	1.102*** [0.151]	0.897*** [0.250]	1.079*** [0.264]	0.865*** [0.157]	1.735*** [0.264]
LNQUAL17405	0.416*** [0.059]		0.175** [0.079]						0.449*** [0.136]
ISYLLRallcause567		0.067 [0.154]	0.033 [0.153]	0.038 [0.156]	-0.033 [0.105]	-0.170 [0.145]		-0.127 [0.132]	-1.235*** [0.288]
LPROFOCCU05		-0.128 [0.081]		-0.418*** [0.092]					
LPC74LTUN05				-0.309*** [0.069]			0.183** [0.081]		
LWORKAGRI05					0.048*** [0.013]	0.047*** [0.013]			
ILAneedCARAN56						0.376 [0.315]			
ISYLLRacExrenal567							-0.326* [0.169]		
ILAmatneedindexpp								0.734*** [0.119]	
Constant	-0.274 [0.721]	-3.210*** [0.920]	-2.722*** [0.924]	-4.523*** [1.593]	-3.145*** [0.780]	-0.836 [2.201]	-0.755 [2.014]	-1.145 [0.869]	-1.676 [1.299]
Observations	151	151	151	151	151	151	151	151	151
R-squared		0.401	0.412	0.395	0.457	0.464	0.441	0.497	
Endogeneity test statistic	1.596								15.227
Endogeneity p-value	0.206								0.000
Kleibergen-Paap LM test statistic	34.219								33.883
Kleibergen-Paap p-value	0.000								0.000
Kleibergen-Paap F statistic	107.256								40.297
Pesaran-Taylor reset statistic	1.800								0.260
Pesaran-Taylor p-value	0.180								0.610
Ramsey reset F statistic		1.144	1.493	2.060	2.677	1.611	1.397	0.840	
Probability > F		0.334	0.219	0.108	0.049	0.190	0.246	0.474	
Hansen-Sargan test statistic									1.785

Robust standard errors in brackets

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

Table A7 continued Estimation path to preferred expenditure specifications for 2005/06

	(1)	(2)	(3)	(4)	(5)	(6)
	PBC 21	PBC 21	PBC 21	PBC 22	PBC 22	PBC 23a
	HI	HI	HI	social care	social care	GMS
	2005/06 spend	2005/6 spend	2005/06 spend	2005/6 spend	2006/07 spend	2005/6 spend
	SYLLR 2005/06/07	SYLLR 2005/6/7	SYLLR 2005/06/07	SYLLR 2005/6/7	SYLLR 2006/07/08	SYLLR 2005/6/7
	spend model	spend model	spend model	spend model	spend model	spend model
	o/need exogenous	instrument o/need	o/need exogenous	instrument o/need	o/need exogenous	instrument n/a
	weighted	weighted	weighted	weighted	weighted	weighted
	OLS	IV second stage	OLS	IV second stage	OLS	OLS
		GMM2S		GMM2S		
	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 census 05	actual census 05	actual census 05	actual census 05	actual census 05	actual census 05
VARIABLES	06/07 specification	re-derived	re-derived OLS	06/07 specification	6/7 spec OLS	06/07 specification
ILAgall_56netpopheadOHP	0.435	0.507	0.456	1.069*	0.612	0.532***
	[0.365]	[0.371]	[0.343]	[0.614]	[0.522]	[0.070]
ISYLLRallcause567	0.828**	0.413	0.470*	-0.893*	-0.440	-0.102*
	[0.385]	[0.342]	[0.254]	[0.532]	[0.441]	[0.052]
LPOPPUCAR05	-0.714	-0.864**	-0.948**			
	[0.547]	[0.381]	[0.390]			
LBORNEXEU05	-0.094	-0.151**	-0.173**			
	[0.058]	[0.067]	[0.071]			
LNQUAL17405	-0.157					
	[0.339]					
LWORKAGRI05		-0.090*	-0.095*			0.035***
		[0.051]	[0.050]			[0.010]
LWHITEEG05						-0.194***
						[0.045]
Constant	-7.112***	-5.832***	-6.097***	1.173	1.663	1.929***
	[2.464]	[2.224]	[2.273]	[2.588]	[2.610]	[0.347]
Observations	151	151	151	116	116	147
R-squared	0.169		0.187		0.015	0.391
Ramsey reset F statistic	1.372		0.735		0.449	0.691
Probability > F	0.254		0.533		0.719	0.559
Endogeneity test statistic		0.304		0.599		
Endogeneity p-value		0.581		0.439		
Hansen-Sargan test statistic		1.658		3.943		
Hansen-Sargan p-value		0.646		0.268		
Kleibergen-Paap LM test statistic		36.779		33.298		
Kleibergen-Paap p-value		0.000		0.000		
Kleibergen-Paap F statistic		50.792		38.220		
Pesaran-Taylor reset statistic		0.527		0.000		
Pesaran-Taylor p-value		0.468		0.984		

Robust standard errors in brackets

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

Appendix 2: Expected health opportunity costs in the NHS (2005/06 results)

Overview

68. In the second appendix results are presented that reflect the available data for 2005/06 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 2005/06 compared to previously generated results

Year	2005/06	2006/07	2007/08	2008/09	2009/10
Cost per QALY	£7,613	£6,844	£9,747	£12,960	£9,887
Health opportunity costs of £10mn (QALYs)	1,314	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 decreased between 2006/07 and 2005/06 and so the cost per QALY ratio has increased. The associated uncertainty with each of these results is presented in Table A9 and figures A1 and A2 below.

Table A9 Probabilistic results for 2005/06 compared to previously generated results

2005/06	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£7,613	£7,635	£5,611	£11,619
Health opportunity costs of £10mn (QALYs)	1,314	1,310	861	1,782
2006/07	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£6,844	£6,838	£5,139	£9,878
Health opportunity costs of £10mn (QALYs)	1,461	1,462	1,012	1,946
2007/08	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£9,747	£9,765	£7,689	£13,043
Health opportunity costs of £10mn (QALYs)	1,026	1,024	767	1,301
2008/09	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£12,960	£13,271	£8,390	£32,881
Health opportunity costs of £10mn (QALYs)	772	754	304	1,192
2009/10	Point estimate (deterministic)	Point estimate (probabilistic)	5th percentile	95th percentile
Cost per QALY	£9,887	£9,920	£6,802	£17,296
Health opportunity costs of £10mn (QALYs)	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 decreased slightly between 2006/07 and 2005/06 and so the cost per QALY ratio has risen. 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 2005/06 and previously generated results – cost per QALY

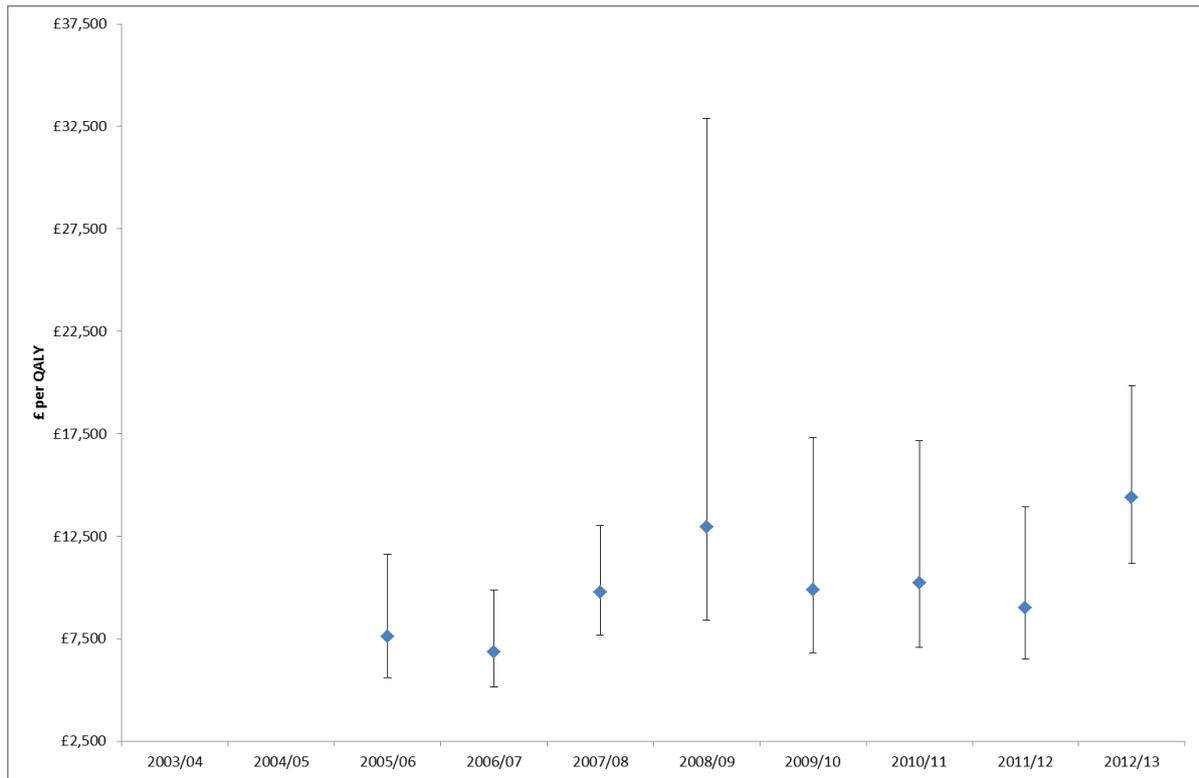
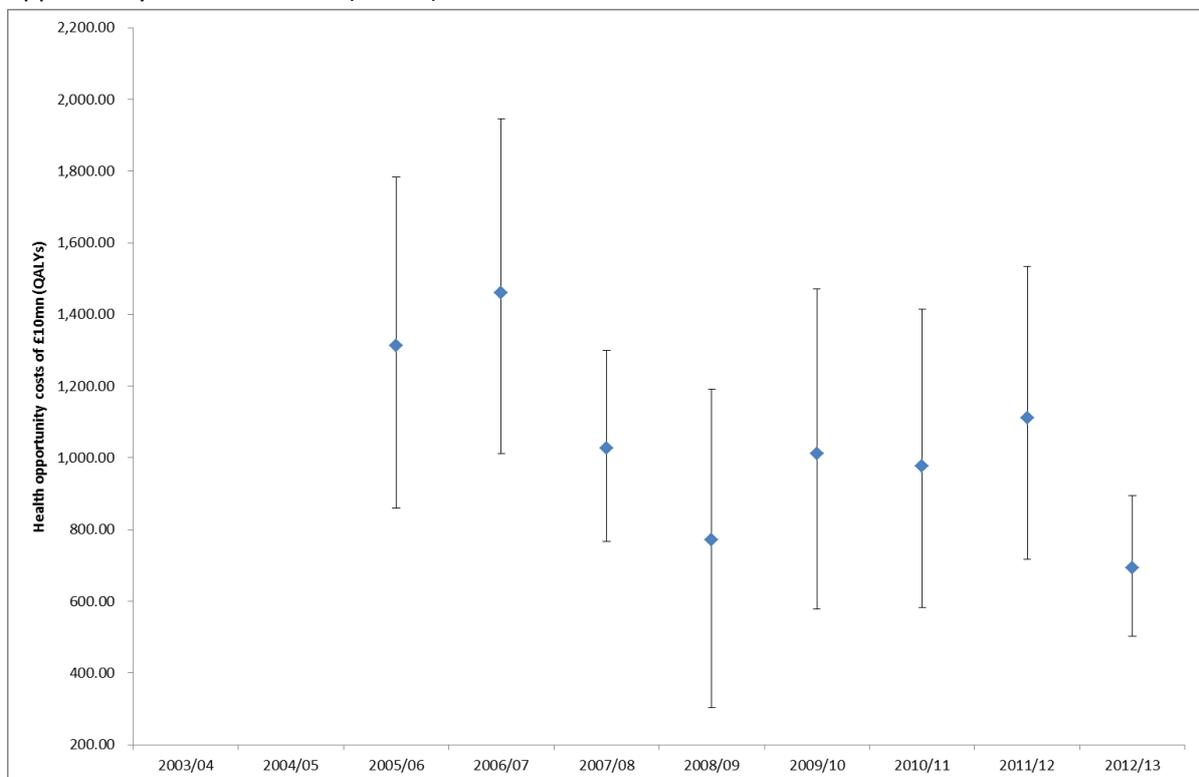


Figure A2 Results illustrating uncertainty for 2005/06 and previously generated results – Health opportunity costs of £10mn (QALYs)



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 (£) 2005/06	Implied PBC cost per QALY (£) 2006/07	Implied PBC cost per QALY (£) 2007/08	Implied PBC cost per QALY (£) 2008/09
2 Cancer	£ 27,667.77	£ 18,273.98	£ 17,640.20	£ 17,594.59
10 Circulatory	£ 4,844.61	£ 5,823.96	£ 6,571.01	£ 6,665.70
11 Respiratory	£ 1,394.46	£ 1,295.46	£ 1,971.96	£ 2,151.60
13 Gastro-intestinal	£ 9,954.11	£ 7,290.71	£ 11,292.57	£ 8,602.65
1 Infectious diseases	£ 19,452.54	£ 12,275.48	£ 12,886.90	£ 19,030.88
4 Endocrine	£ 2,916.06	£ 2,078.60	£ 2,198.46	£ 2,270.96
7 Neurological	£ 4,677.53	£ 2,301.18	£ 9,165.34	£ 7,504.74
17 Genito-urinary	£ 78,439.80	£ 116,616.35	£ 33,836.19	£ 2,978,823.26
16 Trauma & injuries*	N/A	N/A	N/A	N/A
18+19 Maternity & neonates*	£ 7,526,403.52	£ 4,613,479.53	£ 6,260,414.86	£ 12,313,490.13
3 Disorders of Blood	£ 4,703.82	£ 4,053.46	£ 5,977.55	£ 8,676.28
5 Mental Health	£ 8,673.25	£ 8,254.65	£ 11,278.69	£ 17,250.44
6 Learning Disability	£ 69,200.60	£ 65,320.04	£ 92,084.50	£ 137,944.35
8 Problems of Vision	£ 21,838.83	£ 18,951.38	£ 27,118.28	£ 42,138.55
9 Problems of Hearing	£ 2,675.78	£ 2,407.59	£ 3,935.06	£ 5,753.54
12 Dental problems	£ 9,432.19	£ 17,863.94	£ 25,722.64	£ 39,088.10
14 Skin	£ 46,661.01	£ 44,709.25	£ 60,419.56	£ 92,974.01
15 Musculo skeletal	£ 8,159.61	£ 6,620.05	£ 9,469.74	£ 14,382.87
20 Poisoning and AE	£ 49,191.19	£ 45,750.52	£ 62,464.12	£ 104,500.87
21 Healthy Individuals	£ 214,734.17	£ 200,069.12	£ 294,658.13	£ 484,677.80
22 Social Care Needs	N/A	N/A	N/A	N/A
23 Other	N/A	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) 2006/07	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09
2	Cancer	£ 999,160.83	36	£ 27,667.77	55	4.22%	6	6	5	6
10	Circulatory	£ 1,383,957.98	286	£ 4,844.61	202	15.42%	3	2	3	4
11	Respiratory	£ 642,465.45	461	£ 1,394.46	405	30.81%	1	1	1	2
13	Gastro-intestinal	£ 659,566.93	66	£ 9,954.11	81	6.14%	5	4	4	5
1	Infectious diseases	£ 214,481.53	11	£ 19,452.54	22	1.68%	7	7	8	7
4	Endocrine	£ 186,239.98	64	£ 2,916.06	128	9.73%	4	3	2	3
7	Neurological	£ 377,639.63	81	£ 4,677.53	223	16.95%	2	5	6	1
17	Genito-urinary	£ 548,134.04	7	£ 78,439.80	12	0.92%	8	8	7	8
16	Trauma & injuries*	£ 516,775.76	0	N/A	-	-	-	-	-	-
18+19	Maternity & neonates*	£ 481,545.51	0	£ 7,526,403.52	0	0.02%	9	9	9	9
3	Disorders of Blood	£ 195,852.54	42	£ 4,703.82	-	-	-	-	-	-
5	Mental Health	£ 1,187,618.17	137	£ 8,673.25	-	-	-	-	-	-
6	Learning Disability	£ 157,547.24	2	£ 69,200.60	-	-	-	-	-	-
8	Problems of Vision	£ 239,937.18	11	£ 21,838.83	-	-	-	-	-	-
9	Problems of Hearing	£ 36,036.45	13	£ 2,675.78	-	-	-	-	-	-
12	Dental problems	£ 229,875.99	24	£ 9,432.19	-	-	-	-	-	-
14	Skin	£ 169,970.46	4	£ 46,661.01	-	-	-	-	-	-
15	Musculo skeletal	£ 526,833.06	65	£ 8,159.61	-	-	-	-	-	-
20	Poisoning and AE	£ 186,440.01	4	£ 49,191.19	-	-	-	-	-	-
21	Healthy Individuals	£ 100,068.37	0	£ 214,734.17	-	-	-	-	-	-
22	Social Care Needs	£ 270,712.47	0	N/A	-	-	-	-	-	-
23	Other	£ 689,140.42	0	N/A	-	-	-	-	-	-
Total:			1,314							

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) 2006/07	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09	
2	Cancer	£ 999,160.83	36	£ 27,667.77	46	3.52%	4	8	8	11
10	Circulatory	£ 1,383,957.98	286	£ 4,844.61	61	4.61%	2	9	2	2
11	Respiratory	£ 642,465.45	461	£ 1,394.46	133	10.11%	1	1	1	1
13	Gastro-intestinal	£ 659,566.93	66	£ 9,954.11	12	0.91%	12	18	12	13
1	Infectious diseases	£ 214,481.53	11	£ 19,452.54	9	0.69%	14	19	21	19
4	Endocrine	£ 186,239.98	64	£ 2,916.06	12	0.93%	11	12	10	3
7	Neurological	£ 377,639.63	81	£ 4,677.53	6	0.44%	19	6	19	18
17	Genito-urinary	£ 548,134.04	7	£ 78,439.80	43	3.29%	5	4	11	6
16	Trauma & injuries*	£ 516,775.76	0	N/A	52	3.98%	3	7	6	8
18+19	Maternity & neonates*	£ 481,545.51	0	£ 7,526,403.52	32	2.42%	7	2	5	4
3	Disorders of Blood	£ 195,852.54	42	£ 4,703.82	9	0.67%	15	20	18	22
5	Mental Health	£ 1,187,618.17	137	£ 8,673.25	5	0.42%	20	15	20	12
6	Learning Disability	£ 157,547.24	2	£ 69,200.60	22	1.66%	9	5	7	10
8	Problems of Vision	£ 239,937.18	11	£ 21,838.83	10	0.77%	13	16	15	17
9	Problems of Hearing	£ 36,036.45	13	£ 2,675.78	8	0.60%	17	17	13	20
12	Dental problems	£ 229,875.99	24	£ 9,432.19	5	0.41%	21	11	14	14
14	Skin	£ 169,970.46	4	£ 46,661.01	8	0.64%	16	14	16	16
15	Musculo skeletal	£ 526,833.06	65	£ 8,159.61	2	0.15%	22	22	22	21
20	Poisoning and AE	£ 186,440.01	4	£ 49,191.19	6	0.48%	18	21	17	15
21	Healthy Individuals	£ 100,068.37	0	£ 214,734.17	19	1.41%	10	13	9	5
22	Social Care Needs	£ 270,712.47	0	N/A	41	3.11%	6	10	3	7
23	Other	£ 689,140.42	0	N/A	24	1.81%	8	3	4	9

Total: 1,314

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. The overall estimated health opportunity cost is also sensitive to PBCs 7 and 10 (neurological and circulatory).

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) 2006/07	Importance of PBC (rank) 2007/08	Importance of PBC (rank) 2008/09
2 Cancer	£ 999,160.83	34	3	-0.20%	16	15	14	14
10 Circulatory	£ 1,383,957.98	194	91	-6.96%	3	4	3	5
11 Respiratory	£ 642,465.45	12	448	-34.14%	1	1	1	1
13 Gastro-intestinal	£ 659,566.93	24	42	-3.23%	7	6	5	6
1 Infectious diseases	£ 214,481.53	2	9	-0.70%	12	11	10	10
4 Endocrine	£ 186,239.98	3	60	-4.60%	6	3	4	4
7 Neurological	£ 377,639.63	4	77	-5.87%	4	5	7	3
17 Genito-urinary	£ 548,134.04	1	6	-0.42%	13	13	11	18
16 Trauma & injuries*	£ 516,775.76	0	0	0.00%	-	-	-	-
18+19 Maternity & neonates*	£ 481,545.51	0	0	0.00%	19	19	19	19
3 Disorders of Blood	£ 195,852.54	2	39	-3.17%	8	8	8	9
5 Mental Health	£ 1,187,618.17	12	125	-10.42%	2	2	2	2
6 Learning Disability	£ 157,547.24	0	2	-0.17%	17	17	17	15
8 Problems of Vision	£ 239,937.18	0	11	-0.84%	11	12	12	12
9 Problems of Hearing	£ 36,036.45	0	13	-1.03%	10	9	9	8
12 Dental problems	£ 229,875.99	0	24	-1.86%	9	10	13	11
14 Skin	£ 169,970.46	1	2	-0.28%	15	14	16	13
15 Musculo skeletal	£ 526,833.06	3	61	-4.92%	5	7	6	7
20 Poisoning and AE	£ 186,440.01	1	3	-0.29%	14	16	15	16
21 Healthy Individuals	£ 100,068.37	0	0	-0.04%	18	18	18	17
22 Social Care Needs	£ 270,712.47	0	0	0.00%	-	-	-	-
23 Other	£ 689,140.42	0	0	0.00%	-	-	-	-
Total:		295	1,019					
Total change in QALY death + QALY alive			1,314					

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 2005/06

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 2005-2007, 2006-2008, 2007-2009, 2008-2010 and 2009-2011 using LE for each PBC

2005-2007

PBC	GP LE (M)	GP LE (F)	PBC LE (M)	PBC LE (F)	All deaths	Net YLL
1	79.4	83.4	79.4	83.4	6,874	33,965
2	82.8	84.5	82.8	84.5	129,927	1,327,521
4	80.7	84.6	80.7	84.6	6,755	49,589
7	79.4	83.1	79.4	83.1	14,591	91,452
10	82.7	86.3	82.7	86.3	164,630	824,599
11	80.0	83.8	80.0	83.8	65,660	47,301
13	80.3	84.3	80.3	84.3	23,947	217,025
17	83.3	85.4	83.3	85.4	10,100	16,381
18+19	78.5	82.9	78.5	82.9	215	15,833

2006-2008

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

2007-2009

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

2008-2010

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

2009-2011

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

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

79. 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
2005/6	1.37