

ESTIMATING EXPECTED HEALTH OPPORTUNITY COSTS IN THE NHS

(Analysis of 2008/09 Expenditure Data)

YORK TEAM

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Summary

This document comprises of two appendices:

Summary of Appendix 1: Outline of data update, estimation strategy, and results for outcome and expenditure models for 2008/09

Starting point: the 2009/10 specification

1. Identify the preferred specification for the outcome and expenditure equation for each programme budget category (PBC) for 2009/10. The outcome and expenditure elasticities generated by these specifications (when estimated at LA-level) are shown in Table 1.

Re-estimate the 2009/10 specifications using updated data

2. The 2009/10 specifications were derived using a combination PCT-level data mapped to LA-level and direct LA-level data. Backdate PCT-level data to 2008/09 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 2009/10 to 2008/09
- the raw population, unified weighted population, and MFF estimates used and implied by the resource allocations for 2008/09
- PB specific indices of need (eg infectious diseases, mental health, maternity) from the relevant DH resource allocation exposition books (where possible)
- PB specific disease prevalence rates as extracted from the HSCIC's QOF database

3. Obtain LA-level statistics for those variables that are reported at this unit of analysis. This will involve backdating LA-level data for 2009/10 to 2008/09. This will include backdating :

- mortality data for 2009/10/11 with data for 2008/09/10
- census-based variables for 2009 with data for 2008 (by appropriate interpolation between 2001 and 2011).

Estimation strategy for 2008/09: same as for 2009/10

4. Having backdated all data, use the preferred specification for 2009/10 to re-estimate each outcome and expenditure equation for 2008/09.

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 2008/09. This rule is applied to cases where the preferred specification for 2009/10 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 2009/10 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 2009/10 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 2008/09: elasticities from preferred specifications

12. The estimation strategy outlined above generated the outcome and expenditure elasticities for 2008/09 shown in Table 1.

Results for 2008/09: 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 2008/09: estimation path to preferred specifications

14. The full estimation path for each result (starting with the re-estimation of the 2009/10 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 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			
		Outcome elasticity	Re-est. A	Spend elasticity	Re-est. B	Outcome elasticity	Re-est. A	Spend elasticity	Re-est. B	Outcome elasticity	Re-est. A	Spend elasticity	Re-est. B	Outcome elasticity	Re-est. A	Spend elasticity	Re-est. B	Outcome elasticity	Re-est. A	Spend elasticity	Re-est. B	Outcome elasticity	Re-est. A	Spend elasticity	Re-est. B
1	Infectious diseases	-0.310*	A	0.968***	-	-0.549***	A	1.471***	-																
2	Cancers and tumours	-0.345***	-	0.502**	A	-0.287***	-	0.784**	-																
3	Diseases of the blood	n/a		1060***	B	n/a		0.995***	-																
4	Endocrine, nutritional, metabolic	-1.075**	A	0.708***	-	-1.607**	-	0.498***	A																
5	Mental health disorders	n/a		0.899***	-	n/a		0.995***	-																
6	Learning disability	n/a		0.647**	B	n/a		0.329	-																
7	Neurological problems	-1.357	C	0.850***	-	-0.304	C	0.897***	-																
8	Vision problems	n/a		0.934***	A	n/a		0.70***	-																
9	Hearing problems	n/a		1273***	C	n/a		1637***	-																
10	Circulatory problems	-1.842***	-	0.494*	-	-1.384***	-	1.784***	A																
11	Respiratory problems	-2.103***	B	0.576***	-	-1.671***	-	0.752**	-																
12	Dental problems	n/a		0.765***	B	n/a		0.428**	B																
13	Gastro-intestinal problems	-1.989*	A	0.387*	-	-1.116**	A	0.520*	-																
14	Skin problems	n/a		0.890***	D	n/a		0.907***	-																
15	Musculo-skeletal problems	n/a		0.295	B	n/a		0.738***	C																
16	Trauma and injuries	0	B	1090***	-	Tbc		1344***	-																
17	Genito-urinary problems	-2.997	B	0.878***	-	-0.024	C	0.733***	-																
18	Maternity and reproductive health																								
19	Neonates	-0.166*	B	0.653***	-	-0.030	A	0.963***	-																
20	Poisoning and adverse events	n/a		0.658**	-	n/a		2.102***	-																
21	Healthy individuals	n/a		1246**	-	n/a		1049	-																
22	Social care needs	n/a		0.844	B	n/a		1.192*	-																
23	Other (includes GM S/PM S)	n/a		0.564***	B	n/a		0.338***	-																

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

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

Summary of Appendix 2: Expected health opportunity costs in the NHS (2008/09 results)

Overview

15. In the second appendix results are presented that reflect the available data for 2008/09 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 2008/09 compared to previously generated results

2008/09	Point estimate	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	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 2009/10 and 2008/09 and so the cost per QALY ratio has risen. In this table, the uncertainty associated with these estimates is shown and it can be judged to what extent any changes in the point estimate between years should be interpreted as a signal of any trend. 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 2008/09 and previously generated results – cost per QALY

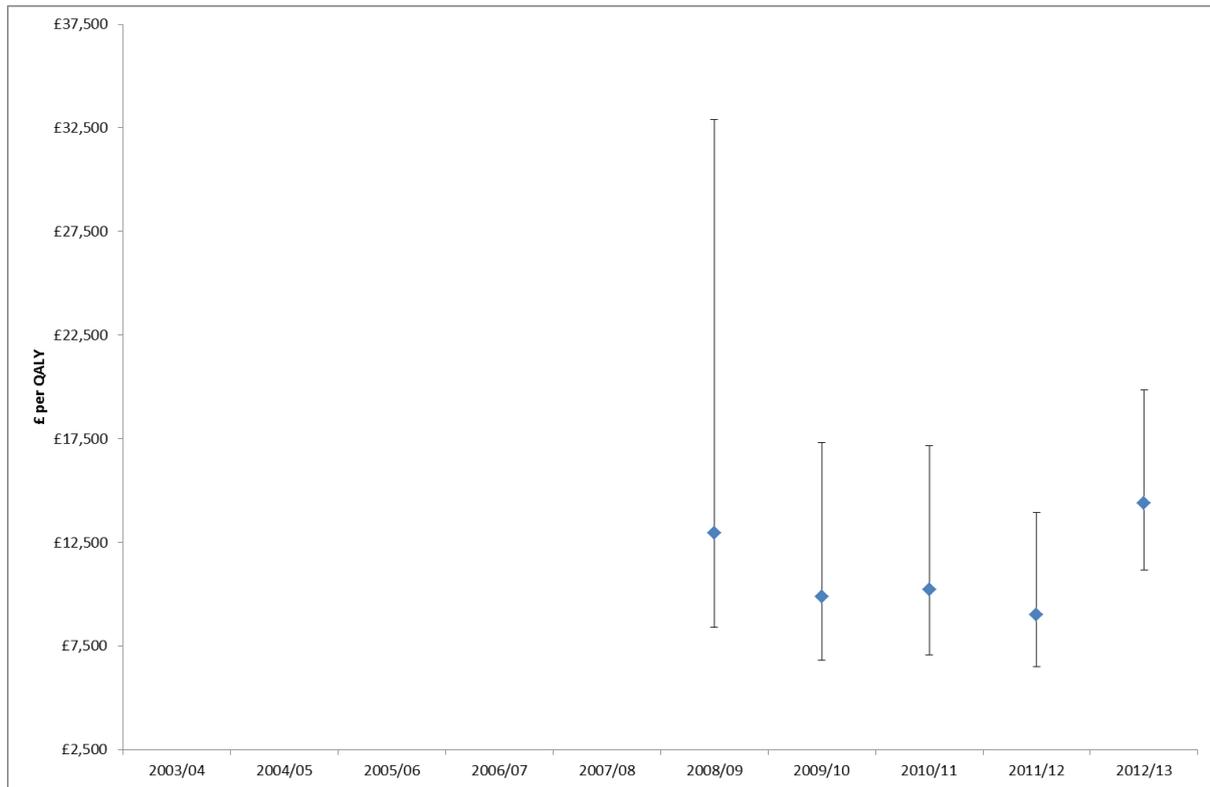
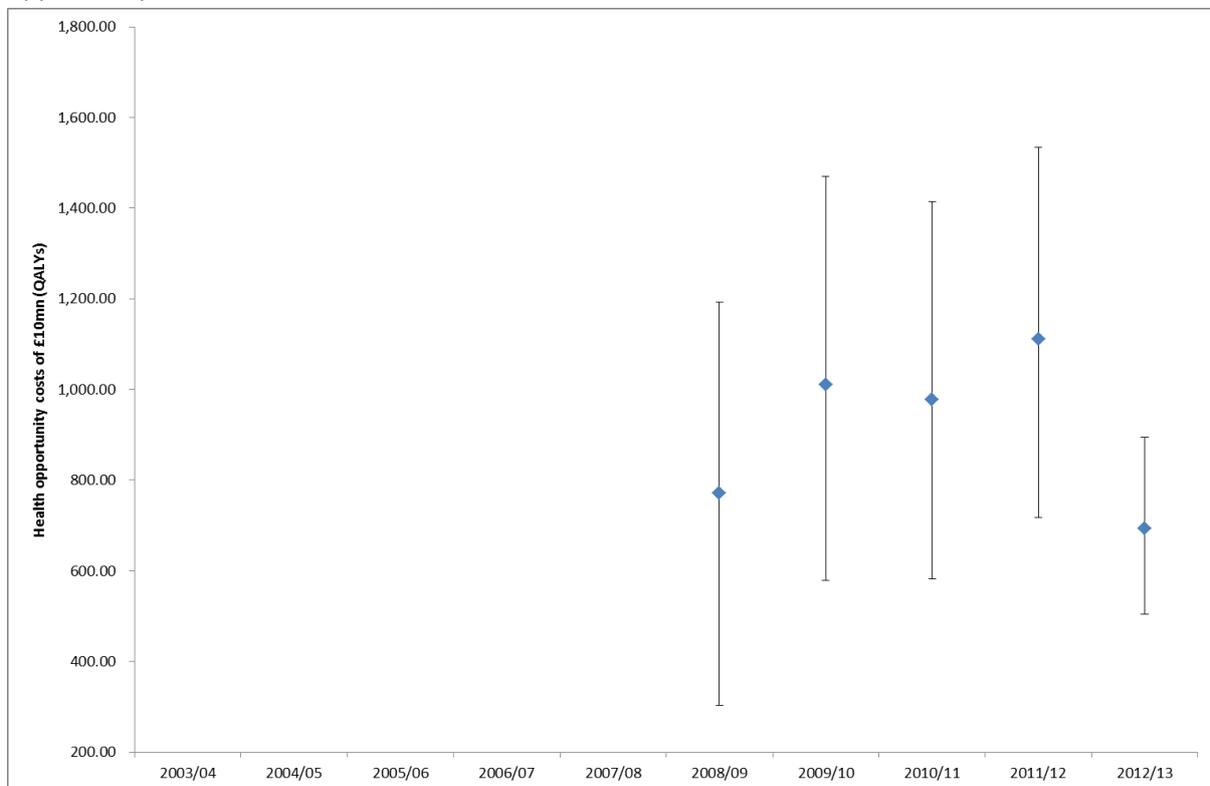


Figure 2 Results illustrating uncertainty for 2008/09 and previously generated results – Health opportunity costs of £10mn (QALYs)



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)
2 Cancer	£ 672,268.42	38	£ 17,594.59	31	4.01%	6
10 Circulatory	£ 723,546.46	109	£ 6,665.70	59	7.68%	4
11 Respiratory	£ 531,742.77	247	£ 2,151.60	182	23.63%	2
13 Gastro-intestinal	£ 367,309.53	43	£ 8,602.65	41	5.34%	5
1 Infectious diseases	£ 312,927.63	16	£ 19,030.88	14	1.83%	7
4 Endocrine	£ 144,398.76	64	£ 2,270.96	66	8.58%	3
7 Neurological	£ 550,260.43	73	£ 7,504.74	322	41.77%	1
17 Genito-urinary	£ 490,436.80	0	£ 2,978,823.26	13	1.73%	8
16 Trauma & injuries*	£ 774,506.00	0	N/A	-	-	-
18+19 Maternity & neonates*	£ 678,330.22	0	£ 12,313,490.13	0	0.05%	9
3 Disorders of Blood	£ 175,984.34	20	£ 8,676.28	-	-	-
5 Mental Health	£ 1,725,449.32	100	£ 17,250.44	-	-	-
6 Learning Disability	£ 167,421.92	1	£ 137,944.35	-	-	-
8 Problems of Vision	£ 209,507.56	5	£ 42,138.55	-	-	-
9 Problems of Hearing	£ 121,109.58	21	£ 5,753.54	-	-	-
12 Dental problems	£ 242,351.65	6	£ 39,088.10	-	-	-
14 Skin	£ 266,052.12	3	£ 92,974.01	-	-	-
15 Musculo skeletal	£ 332,394.07	23	£ 14,382.87	-	-	-
20 Poisoning and AE	£ 111,941.22	1	£ 104,500.87	-	-	-
21 Healthy Individuals	£ 308,557.23	1	£ 484,677.80	-	-	-
22 Social Care Needs	£ 395,495.64	0	N/A	-	-	-
23 Other	£ 698,008.34	0	N/A	-	-	-

Total:

772

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)
2 Cancer	£ 672,268.42	38	£ 17,594.59	14	1.85%	11
10 Circulatory	£ 723,546.46	109	£ 6,665.70	216	28.04%	2
11 Respiratory	£ 531,742.77	247	£ 2,151.60	228	29.50%	1
13 Gastro-intestinal	£ 367,309.53	43	£ 8,602.65	12	1.57%	13
1 Infectious diseases	£ 312,927.63	16	£ 19,030.88	6	0.72%	19
4 Endocrine	£ 144,398.76	64	£ 2,270.96	67	8.65%	3
7 Neurological	£ 550,260.43	73	£ 7,504.74	7	0.88%	18
17 Genito-urinary	£ 490,436.80	0	£ 2,978,823.26	32	4.11%	6
16 Trauma & injuries*	£ 774,506.00	0	N/A	29	3.76%	8
18+19 Maternity & neonates*	£ 678,330.22	0	£ 12,313,490.13	53	6.92%	4
3 Disorders of Blood	£ 175,984.34	20	£ 8,676.28	4	0.48%	22
5 Mental Health	£ 1,725,449.32	100	£ 17,250.44	13	1.66%	12
6 Learning Disability	£ 167,421.92	1	£ 137,944.35	25	3.24%	10
8 Problems of Vision	£ 209,507.56	5	£ 42,138.55	7	0.92%	17
9 Problems of Hearing	£ 121,109.58	21	£ 5,753.54	5	0.68%	20
12 Dental problems	£ 242,351.65	6	£ 39,088.10	12	1.50%	14
14 Skin	£ 266,052.12	3	£ 92,974.01	8	1.00%	16
15 Musculo skeletal	£ 332,394.07	23	£ 14,382.87	4	0.49%	21
20 Poisoning and AE	£ 111,941.22	1	£ 104,500.87	8	1.07%	15
21 Healthy Individuals	£ 308,557.23	1	£ 484,677.80	34	4.41%	5
22 Social Care Needs	£ 395,495.64	0	N/A	31	4.02%	7
23 Other	£ 698,008.34	0	N/A	28	3.68%	9

Total:

772

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)
2 Cancer	£ 672,268.42	35	3	-0.35%	14
10 Circulatory	£ 723,546.46	74	34	-4.42%	5
11 Respiratory	£ 531,742.77	12	235	-30.48%	1
13 Gastro-intestinal	£ 367,309.53	16	27	-3.46%	6
1 Infectious diseases	£ 312,927.63	4	13	-1.63%	10
4 Endocrine	£ 144,398.76	4	60	-7.79%	4
7 Neurological	£ 550,260.43	3	70	-9.12%	3
17 Genito-urinary	£ 490,436.80	0	0	-0.02%	18
16 Trauma & injuries*	£ 774,506.00	0	0	0.00%	-
18+19 Maternity & neonates*	£ 678,330.22	0	0	0.00%	19
3 Disorders of Blood	£ 175,984.34	1	19	-2.63%	9
5 Mental Health	£ 1,725,449.32	9	91	-12.96%	2
6 Learning Disability	£ 167,421.92	0	1	-0.16%	15
8 Problems of Vision	£ 209,507.56	0	5	-0.64%	12
9 Problems of Hearing	£ 121,109.58	0	21	-2.73%	8
12 Dental problems	£ 242,351.65	0	6	-0.80%	11
14 Skin	£ 266,052.12	1	2	-0.37%	13
15 Musculo skeletal	£ 332,394.07	1	22	-3.00%	7
20 Poisoning and AE	£ 111,941.22	0	1	-0.14%	16
21 Healthy Individuals	£ 308,557.23	0	1	-0.08%	17
22 Social Care Needs	£ 395,495.64	0	0	0.00%	-
23 Other	£ 698,008.34	0	0	0.00%	-
Total:		161	611		
Total change in QALY death + QALY alive			772		

Appendix 1: Outline of data update, estimation strategy, and results for outcome and expenditure models for 2008/09

Starting point: the 2009/10 specification

20. Identify the preferred specification for the outcome and expenditure equation for each programme budget category (PBC) for 2009/10. The outcome and expenditure elasticities generated by these specifications (when estimated at LA-level) are shown in Table A1.

Re-estimate the 2009/10 specifications using updated data

21. The 2009/10 specifications were derived using a combination PCT-level data mapped to LA-level and direct LA-level data. Backdate PCT-level data to 2008/09 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 2009/10 to 2008/09
- the raw population, unified weighted population, and MFF estimates used and implied by the resource allocations for 2008/09
- PB specific indices of need (eg infectious diseases, mental health, maternity) from the relevant DH resource allocation exposition books (where possible)
- PB specific disease prevalence rates as extracted from the HSCIC's QOF database

22. Obtain LA-level statistics for those variables that are reported at this unit of analysis. This will involve backdating LA-level data for 2009/10 to 2008/09. This will include backdating :

- mortality data for 2009/10/11 with data for 2008/09/10
- census-based variables for 2009 with data for 2008 (by appropriate interpolation between 2001 and 2011).

Estimation strategy for 2008/09: same as for 2009/10

23. Having backdated all data, use the preferred specification for 2009/10 to re-estimate each outcome and expenditure equation for 2008/09.

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 2008/09. This rule is applied to cases where the preferred specification for 2009/10 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 2009/10 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 2009/10 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 2008/09: elasticities from preferred specifications

31. The estimation strategy outlined above generated the outcome and expenditure elasticities for 2008/09 shown in Table A1.

Results for 2008/09: 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 2008/09: estimation path to preferred specifications

33. The full estimation path for each result (starting with the re-estimation of the 2009/10 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 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			
		Outcome elasticity	Re-est. A	Spend elasticity	Re-est. B	Outcome elasticity	Re-est. A	Spend elasticity	Re-est. B	Outcome elasticity	Re-est. A	Spend elasticity	Re-est. B	Outcome elasticity	Re-est. A	Spend elasticity	Re-est. B	Outcome elasticity	Re-est. A	Spend elasticity	Re-est. B	Outcome elasticity	Re-est. A	Spend elasticity	Re-est. B
1	Infectious diseases	-0.310*	A	0.968***	-	-0.549***	A	1.471***	-																
2	Cancers and tumours	-0.345***	-	0.502**	A	-0.287***	-	0.784**	-																
3	Diseases of the blood	n/a		1060***	B	n/a		0.995***	-																
4	Endocrine, nutritional, metabolic	-1.075**	A	0.708***	-	-1.607**	-	0.498***	A																
5	Mental health disorders	n/a		0.899***	-	n/a		0.995***	-																
6	Learning disability	n/a		0.647**	B	n/a		0.329	-																
7	Neurological problems	-1.357	C	0.850***	-	-0.304	C	0.897***	-																
8	Vision problems	n/a		0.934***	A	n/a		0.70***	-																
9	Hearing problems	n/a		1.273***	C	n/a		1.637***	-																
10	Circulatory problems	-1.842***	-	0.494*	-	-1.384***	-	1.784***	A																
11	Respiratory problems	-2.103***	B	0.576***	-	-1.671***	-	0.752**	-																
12	Dental problems	n/a		0.765***	B	n/a		0.428**	B																
13	Gastro-intestinal problems	-1.989*	A	0.387*	-	-1.116**	A	0.520*	-																
14	Skin problems	n/a		0.890***	D	n/a		0.907***	-																
15	Musculo-skeletal problems	n/a		0.295	B	n/a		0.738***	C																
16	Trauma and injuries	0	B	1.090***	-	Tbc		1.344***	-																
17	Genito-urinary problems	-2.997	B	0.878***	-	-0.024	C	0.733***	-																
18	Maternity and reproductive health																								
19	Neonates	-0.166*	B	0.653***	-	-0.030	A	0.963***	-																
20	Poisoning and adverse events	n/a		0.658**	-	n/a		2.102***	-																
21	Healthy individuals	n/a		1.246**	-	n/a		1.049	-																
22	Social care needs	n/a		0.844	B	n/a		1.192*	-																
23	Other (includes GM S/PM S)	n/a		0.564***	B	n/a		0.338***	-																

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

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

Part A Overview of results by PBC

Infectious diseases

34. Outcome: Re-estimation of the 2009/10 specification using updated data suggests that the instrument set is weak (see Table A6). Dropping the least significant instrument generates a much stronger instrument set and an acceptable result (see Table A4 and Table A6).

35. Expenditure: Re-estimation of the 2009/10 specification generates an acceptable result, both statistically and in line with priors (see Table A5 and Table A7).

Cancer and tumours

36. Outcome: Re-estimation of the 2009/10 specification with updated data generates an acceptable result (see Table A4 and Table A6).

37. Expenditure: Re-estimation of the 2009/10 specification generates a reasonable result (see Table A5 and Table A7).

Blood disorders

38. Expenditure: Re-estimation of the 2009/10 specification generates an acceptable result (see Table A5 and Table A7).

Endocrine, nutritional and metabolic

39. Outcome: The 2009/10 specification generates an acceptable result (Table A4 and Table A6).

40. Expenditure: The 2009/10 specification generates an OK result but the coefficient on total budget is insignificant (Table A7). Replacement of the need indicator with the 'no qualifications' variable generates an acceptable result but 'other need' is not endogenous. Re-estimation using OLS generates the result shown in Table A5 and Table A7.

Mental health disorders

41. Expenditure: The 2009/10 specification generates an acceptable result (Table A5 and Table A7).

Learning disability

42. Expenditure: The 2009/10 specification generates an insignificant coefficient on total budget but re-derivation offers no improvement so we persevere with this specification (Table A5 and Table A7).

Neurological problems

43. Outcome: The 2009/10 specification generates a poor result with a weak instrument (see Table A6). Tried to find an additional instrument to improve situation but no luck with this and re-derivation also generates a poor result (see Table A6). However, re-estimation using the preferred PCT-level specification for 2008/09 generates an acceptable result (Table A4 and Table A6).

44. Expenditure: The 2009/10 specification generates an acceptable result (Table A5 and Table A7).

Problems of vision

45. Expenditure: The 2009/10 specification generates an acceptable result (Table A5 and Table A7).

Problems of hearing

46. Expenditure: The 2009/10 specification generates an acceptable result (Table A5 and Table A7).

Circulatory problems

47. Outcome: The 2009/10 specification generates an acceptable result (Table A4 and Table A6).

48. Expenditure: The 2009/10 specification generates an insignificant coefficient on total budget (Table A7). Replacement of this regressor with the 'no qualifications' variable generates a significant positive coefficient (Table A5 and Table A7).

Respiratory problems

49. Outcome: The 2009/10 generates an acceptable result (see Table A4 and Table A6).

50. Expenditure: The 2009/10 specification generates an acceptable result (Table A5 and Table A7).

Dental problems

51. Expenditure: The 2009/10 specification generates a poor result with significant positive coefficient on 'other need' and a failed reset test (see Table A7). Re-derivation of an IV specification generates an acceptable result but 'other need' is not endogenous (see Table A7). The OLS version of this re-derived specification is OK (see Table A5).

Gastro-intestinal problems

52. Outcome: The 2009/10 specification is OK and re-estimation without the insignificant regressor (CARAN need squared) has little effect (see Table A4 and Table A6).

53. Expenditure: The 2009/10 specification generates an acceptable result (Table A5 and Table A7).

Skin problems

54. Expenditure: The 2009/10 specification generates an acceptable result (see Table A5 and Table A7).

Musculo-Skeletal system

55. Expenditure: The coefficient on budget is small and insignificant when the 2009/10 specification is re-estimated with updated data for 2008/09 (Table A7). Re-derivation of the IV specification generates a significant positive coefficient on 'other need' but the addition of an extra regressor ('no qualifications' (see Table A7)) and OLS re-estimation (because 'other need' is not endogenous) generates an acceptable result (Table A5 and A7).

Trauma and injuries

56. Outcome: We had been unable to obtain a plausible specification/result using the 2009/10 expenditure and associated outcome data. For 2008/09 (as for 2009/10), we have SMR<75 for skull fractures and SMR<75 for femur fractures as potential outcome measures. However, many of the femur fracture observations are missing at LA-level so we use the skull fracture data as our outcome measure. We derived an IV specification but this was problematic (positive coefficient on expenditure, weak instruments, expenditure not endogenous). We also tried re-deriving but excluding expenditure outliers beyond the 5th and 95th percentiles. However, the coefficient on expenditure is still positive and expenditure appears not to be endogenous (Table A6). We therefore re-estimated using OLS but the coefficient on expenditure is still positive (Table A6).

57. Expenditure: The 2009/10 specification generates an OK result (Table A5 and Table A7).

Genito-urinary system

58. Outcome: The 2009/10 specification generates a poor result (see Table A6). Re-derivation of an IV specification also generates a poor result (eg positive coefficient on expenditure) so we reverted to the preferred PCT-level specification for 2008/09 and re-estimated this at local authority level. This result is OK but expenditure is not endogenous so we re-estimated this specification using OLS (see Table A4 and Table A6).

59. Expenditure: The 2009/10 specification generates an acceptable result (Table A5 and Table A7).

Maternity/Neonates

60. Outcome: The 2009/10 specification generates a poor result in the sense that the coefficient on expenditure is positive (see Table A6). However, we tried adding an extra regressor and re-estimating, and this process revealed that the addition of either the 'lone parent' variable or the 'long-term unemployed' variable generated a negative coefficient on spend and a significant coefficient on the additional regressor (Table A4 and Table A6).

61. Expenditure: The 2009/10 specification generates an acceptable result (Table A5 and Table A7). [Re-derivation of the IV specification offers no improvement and OLS of the 2009/10 version generates a very similar result.]

Poisoning

62. Expenditure: The 2009/10 specification generates an acceptable result (Table A5 and Table A7).

Healthy Individuals

63. Expenditure: The 2009/10 specification generates an acceptable result (Table A5 and Table A7).

Social Care

64. Expenditure: The 2009/10 specification generates an acceptable result (see Table A5 and Table A7). [Note that the sample restriction to LAs with expenditure per head of between £15 and £75 is the same as that employed for 2009/10. This is necessary because there is a large number of 'outliers'].

GMS/PMS

65. Expenditure: The 2009/10 specification generates an acceptable result (see Table A5 and Table A7).

All PBCs: Comparing specifications for 2009/10 and 2010/11

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 2008/09 is OLS and this is the same/similar specification as was preferred for the previous year (i.e., we do not re-derive the OLS specification).

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

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

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

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

APPENDIX

Part B Preferred specifications for outcome and expenditure models for 2008/09

In this section, Tables A4 and A5 provide details of our preferred specification for each outcome and expenditure model by PBC for 2008/09.

Table A4 Preferred outcome specifications for 2008/09

	(1) PBC 1 infectious 2008/9 spend	(2) PBC 2 cancer 2009/10 spend	(3) PBC 4 endocrine 2008/9 spend	(4) PBC 7 neurological 2008/9 spend	(5) PBC 10 circulatory 2008/9 spend	(6) PBC 11 respiratory 2008/9 spend	(7) PBC 13 gastro 2008/9 spend	(8) PBC 17 genito-urinary 2008/9 spend	(9) PBC 1819 mat/neonates 2008/09 spend infant mort rate 2008/09/10 outcome model spend exogenous weighted OLS
VARIABLES	SYLLR 2008/9/10 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 revised	SYLLR 2009/10/11 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census08 09/10 specification	SYLLR 2008/9/10 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 specification	SYLLR 2008/9/10 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 08 PCT specification	SYLLR 2008/9/10 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 specification	SYLLR 2008/9/10 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 specification	SYLLR 2008/9/10 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 revised	SYLLR 2008/9/10 outcome model instrument n/a weighted OLS LA-level actual mortality actual census 08 PCT specification	SYLLR 2008/9/10 outcome model instrument spend weighted OLS LA-level actual mortality actual census 08 09/10 specification+
ILAg1_89netpopphhead	-0.549*** [0.201]								
ILAhivneedph	0.472*** [0.086]								
ILAhivneedph2	0.168*** [0.046]								
ILAimd_2007exexpobook	0.563*** [0.077]		0.690*** [0.180]						
ILAg2_89netpopphheadOHP		-0.287*** [0.076]							
ILAneedCARAN		0.953*** [0.092]		1.254 [0.763]	2.924*** [0.274]	1.913* [0.990]	3.774*** [0.601]		1.630*** [0.294]
ILAg4_89netpopphheadOHP			-1.607** [0.802]						
LPROFOCCU08			-0.851** [0.368]						
ILAg7_89netpopphheadOHP				-0.304 [0.641]					
ILAg10_89netpopphheadOHP					-1.384***				

ILag11_89netpopheadOHP					[0.209]	-1.671***			
LPERMSICK08						[0.504]			
LPERMSICK08SQ						3.922***			
						[1.287]			
ILag13_89netpopheadOHP						0.457**			
						[0.192]			
LLONEPARH08							-1.146**		
							[0.451]		
ILag17_89netpopheadOHP								1.455***	
								[0.359]	
ILag1819_89netpopheadOHP								-0.024	
								[0.533]	
LBORNEXEU08									-0.030
									[0.091]
LHHNOCAR08									0.228***
									[0.043]
LPC74LTUN08									-0.527***
									[0.105]
Constant	1.873***	6.277***	4.188*	2.757	11.178***	18.058***	8.100***	3.126	2.582***
	[0.488]	[0.349]	[2.205]	[2.697]	[1.018]	[3.907]	[1.957]	[2.877]	[0.633]
Observations	148	152	149	148	152	151	150	143	151
R-squared								0.134	0.442
Endogeneity test statistic	3.777	10.300	4.581	0.931	25.219	15.773	11.326		
Endogeneity p-value	0.052	0.001	0.032	0.334	0.000	0.000	0.001		
Hansen-Sargan test statistic	2.602	0.523		3.587	0.566	2.626			
Hansen-Sargan p-value	0.272	0.470		0.166	0.452	0.105			
Kleibergen-Paap LM test statistic	22.335	25.882	9.327	16.084	24.567	11.562	13.871		
Kleibergen-Paap p-value	0.000	0.000	0.002	0.001	0.000	0.003	0.000		
Kleibergen-Paap F statistic	10.459	32.476	10.515	10.630	43.471	14.269	28.799		
Pesaran-Taylor reset statistic	0.028	0.123	0.911	1.459	0.017	0.154	0.627		
Pesaran-Taylor p-value	0.867	0.726	0.340	0.227	0.897	0.695	0.429		
Ramsey reset F statistic								0.731	0.339
Probability > F								0.535	0.797

Robust standard errors in brackets

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

Table A5 Preferred expenditure specifications for 2008/09

	(1) PBC 1 infectious 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 specification	(2) PBC 2 cancer 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 specification	(3) PBC 3 blood 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 specification	(4) PBC 4 endocrine 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 revised OLS	(5) PBC 5 mental health 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 specification	(6) PBC 6 LDisability 2008/09 spend SYLLR 2008/09/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 specification	(7) PBC 7 neurological 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 specification	(8) PBC 8 vision 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 specification
VARIABLES								
ILAgall_89netpopheadOHP	1.471*** [0.261]	0.784** [0.335]	0.995*** [0.272]	0.498*** [0.147]	0.995*** [0.192]	0.329 [0.351]	0.897*** [0.204]	0.701*** [0.223]
ILAhivneedph	0.456*** [0.026]							
Ireal_LAallcausedsyllr890exlandP	-0.429** [0.214]							
ILAhivneedph2	0.181*** [0.023]							
Ireal_LAallcausedsyllr890excanc		-1.184*** [0.168]						
ILAneedCARAN		1.395*** [0.468]						
LPROFOCCU08		-0.348*** [0.094]				-0.516** [0.253]		
Ireal_LAallcausedsyllr890			-0.672** [0.265]		-0.303*** [0.112]	-0.460* [0.273]		-0.544** [0.213]
LLONEPARH08			0.535*** [0.152]					
LNQUAL17408				1.217*** [0.398]				0.664*** [0.079]
LNQUAL17408SQ				0.347*** [0.129]				
ILAdiaprevinover17				0.285** [0.116]				
Ireal_LAallcausedsyllr890exDIA				0.097 [0.105]				
ILAmhneedindexpp					0.658*** [0.143]			
LPOPPUCAR08					-0.618*** [0.104]			
ILAneedCARAN2						3.556**		

Ireal_LAallcausedsyllr890exepi						[1.393]	-0.132	
ILAepilepsyov18prevrate							0.382***	
Constant	-5.190***	5.048*	1.139	0.073	-1.644	3.663*	-1.466	2.541**
	[1.130]	[2.695]	[1.594]	[0.976]	[1.724]	[2.101]	[0.992]	[1.057]
Observations	150	152	152	150	152	152	150	152
R-squared	0.783		0.194	0.579	0.789	0.104		
Ramsey reset F statistic	1.513		1.512	1.186	0.465	1.764		
Probability > F	0.214		0.214	0.317	0.707	0.157		
Endogeneity test statistic		19.732					8.533	4.237
Endogeneity p-value		0.000					0.003	0.040
Hansen-Sargan test statistic		1.028					0.081	0.592
Hansen-Sargan p-value		0.311					0.776	0.442
Kleibergen-Paap LM test statistic		36.285					32.990	34.619
Kleibergen-Paap p-value		0.000					0.000	0.000
Kleibergen-Paap F statistic		56.425					82.270	51.873
Pesaran-Taylor reset statistic		0.002					0.809	0.143
Pesaran-Taylor p-value		0.968					0.368	0.705
Robust standard errors in brackets								
*** p<0.01, ** p<0.05, * p<0.1								

Table A5 continued Preferred expenditure specifications for 2008/09

	(1) PBC 9 hearing 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 specification	(2) PBC 10 circulatory 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 spec revised	(3) PBC 11 respiratory 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 specification	(4) PBC 12 dental 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 rederived OLS	(5) PBC 13 gastro 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 specification	(6) PBC 14 skin problems 2008/09 spend SYLLR 2008/09/11 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 specification	(7) PBC 15 musculo-skeletal 2008/09 spend SYLLR 2008/09/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 re-derived+ OLS	(8) PBC 16 trauma 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 specification
ILAgall_89netpopheadOHP	1.637*** [0.369]	1.784*** [0.276]	0.752** [0.352]	0.428** [0.198]	0.520* [0.278]	0.907*** [0.199]	0.738*** [0.195]	1.344*** [0.222]
LOWNOCC08	0.377 [0.255]			0.278** [0.110]				
Ireal_LAallcausedsyllr890	0.143 [0.320]			0.279 [0.193]		0.001 [0.123]		-0.271 [0.170]
Ireal_LAallcausedsyllr890excirc		-1.271*** [0.236]						
LNQUAL17408		0.515*** [0.087]					0.160 [0.152]	
Ireal_LAallcausedsyllr890exresp			-1.099*** [0.285]					
ILAneedCARAN			1.987*** [0.418]		2.117*** [0.434]			
ILAneedCARAN2			1.109** [0.530]					
ILaimd_2007exexpobook				0.199* [0.111]		0.256** [0.108]		
Ireal_LAallcausedsyllr890exgast					-1.309*** [0.323]			
LHHNOCAR08						-0.222*** [0.074]		
LPC74LTUN08							-0.305*** [0.080]	
LPOPPUCAR08							0.681*** [0.224]	
Ireal_LAsyllr890							0.271 [0.170]	
LWORKAGRI08								0.084*** [0.018]

Constant	-10.672*** [1.776]	-0.118 [1.402]	5.422* [2.892]	-1.183 [1.513]	8.403*** [2.751]	-4.278*** [1.256]	-2.206 [1.617]	-3.653*** [0.989]
Observations	152	152	152	152	152	152	152	152
R-squared	0.256			0.501		0.495	0.541	0.348
Ramsey reset F statistic	0.130			3.756		1.203	1.296	0.793
Probability > F	0.942			0.012		0.311	0.278	0.500
Endogeneity test statistic		31.218	17.243		14.052			
Endogeneity p-value		0.000	0.000		0.000			
Hansen-Sargan test statistic		0.278	0.097		0.009			
Hansen-Sargan p-value		0.598	0.756		0.924			
Kleibergen-Paap LM test statistic		28.178	34.175		32.639			
Kleibergen-Paap p-value		0.000	0.000		0.000			
Kleibergen-Paap F statistic		29.651	34.268		22.222			
Pesaran-Taylor reset statistic		0.232	0.092		0.391			
Pesaran-Taylor p-value		0.630	0.761		0.532			

Robust standard errors in brackets

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

Table A5 continued Preferred expenditure specifications for 2008/09

	(1)	(2)	(3)	(4)	(5)	(6)
	PBC 17 genito- 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 specification	PBC 1819 maternity 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 specification	PBC 20 poisoning 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level real mortality actual census 08 09/10 specification	PBC 21 HI 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality 09/10 specification	PBC 22 social care 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality 09/10 specification	PBC 23a GMS 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 specification
VARIABLES						
LBORNEXEU08	0.037** [0.016]					
Ireal_LAallcausedsyllr890exrenal	-0.040 [0.130]					
ILAneedCARAN	0.251 [0.299]		2.102*** [0.546]	1.049 [0.809]		
ILAgall_89netpopheadOHP	0.733*** [0.213]	0.963*** [0.339]	0.674* [0.366]	0.952 [0.699]	1.192* [0.605]	0.338*** [0.089]
Ireal_LAallcausedsyllr890		-0.299 [0.341]	-1.433*** [0.356]	0.076 [0.326]	-0.463 [0.410]	-0.028 [0.071]
ILAmatneedindexpp		0.809*** [0.135]				
Constant	-0.747 [1.897]	-0.903 [0.819]	6.637* [3.581]	-3.945 [5.837]	-2.416 [3.223]	2.672*** [0.350]
Observations	152	152	152	152	106	150
R-squared	0.491			0.368	0.049	0.228
Ramsey reset F statistic	1.741			0.317	0.331	0.753
Probability > F	0.161			0.813	0.803	0.522
Endogeneity test statistic		1.649	19.393			
Endogeneity p-value		0.199	0.000			
Hansen-Sargan test statistic		2.648	0.006			
Hansen-Sargan p-value		0.266	0.936			
Kleibergen-Paap LM test statistic		15.039	33.275			
Kleibergen-Paap p-value		0.002	0.000			
Kleibergen-Paap F statistic		11.224	33.862			
Pesaran-Taylor reset statistic		0.215	0.029			
Pesaran-Taylor p-value		0.643	0.865			

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 2008/09

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 2008/09. For each PBC, we first estimate the model for 2008/09 using our preferred specification for 2009/10. 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 2008/09 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 2008/09

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	PBC 1	PBC 1	PBC 2	PBC 4	PBC 7	PBC 7	PBC 7	PBC 10	PBC 11	PBC 13
	infectious	infectious	cancer	endocrine	neurological	neurological	neurological	circulatory	respiratory	gastro
	2008/9 spend	2008/9 spend	2009/10 spend	2008/9 spend	2008/9 spend	2008/9 spend	2008/9 spend	2008/9 spend	2008/9 spend	2008/9 spend
	SYLLR	SYLLR	SYLLR	SYLLR	SYLLR	SYLLR	SYLLR	SYLLR	SYLLR	SYLLR
	2008/9/10	2008/9/10	2009/10/11	2008/9/10	2008/9/10	2008/9/10	2008/9/10	2008/9/10	2008/9/10	2008/9/10
	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model	outcome model
	instrument	instrument	instrument	instrument	instrument	instrument	instrument	instrument	instrument	instrument
	spend	spend	spend	spend	spend	spend	spend	spend	spend	spend
	weighted	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	IV second stage	IV second stage	IV second stage
	GMM2S	GMM2S	GMM2S	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	LA-level
	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality	actual mortality
	actual census 08	actual census 08	actual census08	actual census 08	actual census 08	actual census 08	actual census 08	actual census 08	actual census 08	actual census 08
	09/10	09/10	09/10	09/10	09/10	09/10	PCT	09/10	09/10	09/10
VARIABLES	specification	09/10 revised	specification	specification	specification	re-derived	specification	specification	specification	specification
lLag1_89netpophead	-0.549*** [0.198]	-0.549*** [0.201]								
lLAhivneedph	0.472*** [0.085]	0.472*** [0.086]								
lLAhivneedph2	0.168*** [0.045]	0.168*** [0.046]								
lLAimd_2007exexpobook	0.563*** [0.077]	0.563*** [0.077]		0.690*** [0.180]						
lLag2_89netpopheadOHP			-0.287*** [0.076]							
lLANeedCARAN			0.953*** [0.092]		7.325 [11.029]	1.024 [0.797]	1.254 [0.763]	2.924*** [0.274]	1.913* [0.990]	3.741*** [0.571]

ILAg4_89netpopheadOHP				-1.607**						
LPROFOCCU08				[0.802]						
				-0.851**						
				[0.368]						
ILAg7_89netpopheadOHP					-9.545	0.187	-0.304			
					[15.134]	[0.680]	[0.641]			
ILAepilepsyov18prevrate					4.737					
					[6.678]					
LBORNEXEU08					0.293	0.113*				
					[0.463]	[0.060]				
LWORKAGRI08						0.091**				
						[0.043]				
ILAg10_89netpopheadOHP								-1.384***		
								[0.209]		
ILAg11_89netpopheadOHP									-1.671***	
									[0.504]	
LPERMSICK08									3.922***	
									[1.287]	
LPERMSICK08SQ									0.457**	
									[0.192]	
ILAg13_89netpopheadOHP										-1.099**
										[0.428]
ILANeedCARAN2										1.751
										[1.070]
Constant	1.870***	1.873***	6.277***	4.188*	43.741	1.461	2.757	11.178***	18.058***	7.865***
	[0.478]	[0.488]	[0.349]	[2.205]	[66.537]	[2.914]	[2.697]	[1.018]	[3.907]	[1.857]
Observations	148	148	152	149	148	148	148	152	151	150
Endogeneity test statistic	4.178	3.777	10.300	4.581	4.835	0.024	0.931	25.219	15.773	11.919
Endogeneity p-value	0.041	0.052	0.001	0.032	0.028	0.877	0.334	0.000	0.000	0.001
Hansen-Sargan test statistic	2.602	2.602	0.523			4.003	3.587	0.566	2.626	
Hansen-Sargan p-value	0.457	0.272	0.470			0.135	0.166	0.452	0.105	
Kleibergen-Paap LM test statistic	22.450	22.335	25.882	9.327	0.415	15.335	16.084	24.567	11.562	14.098
Kleibergen-Paap p-value	0.000	0.000	0.000	0.002	0.520	0.002	0.001	0.000	0.003	0.000
Kleibergen-Paap F statistic	8.307	10.459	32.476	10.515	0.410	7.147	10.630	43.471	14.269	28.940
Pesaran-Taylor reset statistic	0.058	0.028	0.123	0.911	0.004	0.155	1.459	0.017	0.154	1.125
Pesaran-Taylor p-value	0.810	0.867	0.726	0.340	0.947	0.694	0.227	0.897	0.695	0.289

Robust standard errors in brackets

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

Table A6 continued Estimation path to preferred outcome specifications for 2008/09

	(1) PBC 13 gastro 2008/9 spend SYLLR 2008/9/10 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 08	(2) PBC 16 trauma 2008/9 spend SkullSMR75 2008/9/10 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 08	(3) PBC 16 trauma 2008/9 spend SkullSMR75 2008/9/10 outcome model instrument n/a weighted OLS LA-level actual mortality actual census 08	(4) PBC 17 genito-urinary 2008/9 spend SYLLR 2008/9/10 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10	(5) PBC 17 genito-urinary 2008/9 spend SYLLR 2008/9/10 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 08	(6) PBC 17 genito-urinary 2008/9 spend SYLLR 2008/9/10 outcome model instrument spend weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 PCT	(7) PBC 17 genito-urinary 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 PCT	(8) PBC 1819 mat/neonates 2008/09 spend infant mort rate 2008/09/10 outcome model spend exogenous weighted OLS LA-level actual mortality actual census 08	(9) PBC 1819 mat/neonates 2008/09 spend infant mort rate 2008/09/10 outcome model spend exogenous weighted OLS LA-level actual mortality actual census 08
VARIABLES	09/10 revised	09/10 re-derived	09/10 re-derived	specification	09/10 rederived	specification	specification	09/10 specification	09/10 specification+
ILAg16_89netpopheadOHP		0.357 [0.446]	0.101 [0.193]						
LPC74LTUN08		-0.536** [0.223]	-0.620*** [0.190]						0.354*** [0.114]
LLONEPENH08		-0.782*** [0.279]	-0.762*** [0.259]		-2.035*** [0.670]				
ILAg13_89netpopheadOHP	3.774*** [0.601]	2.243*** [0.699]	2.548*** [0.514]					2.049*** [0.306]	1.630*** [0.294]
ILAg17_89netpopheadOHP				0.499 [0.813]	0.523 [0.758]	-0.346 [1.490]	-0.024 [0.533]		
ILApcent18ovwithckd				0.287 [0.388]					
LOWNOCC08				-1.097** [0.540]					
LWHITEEG08				-1.413*** [0.451]					
LWORKAGRI08				0.027 [0.113]					
LPOPPUCAR08					-2.485*** [0.941]				
LNQUAL17408					1.639*** [0.523]				
LLONEPARH08						1.634** [0.651]	1.455*** [0.359]		
ILAg1819_89netpopheadOHP								0.018 [0.092]	-0.030 [0.091]
LBORNEXEU08								0.255*** [0.047]	0.228*** [0.043]
LHHNOCAR08								-0.392*** [0.102]	-0.527*** [0.105]
Constant	8.100***	-4.929**	-4.183***	-3.960	-10.786***	5.002	3.126	1.138***	2.582***

	[1.957]	[1.955]	[1.397]	[2.972]	[3.011]	[7.969]	[2.877]	[0.424]	[0.633]
Observations	150	139	139	141	141	141	143	151	151
R-squared			0.250				0.134	0.408	0.442
Endogeneity test statistic	11.326	0.578		0.199	0.172	0.027			
Endogeneity p-value	0.001	0.447		0.656	0.679	0.869			
Kleibergen-Paap LM test statistic	13.871	7.059		33.294	28.661	14.033			
Kleibergen-Paap p-value	0.000	0.029		0.000	0.000	0.001			
Kleibergen-Paap F statistic	28.799	10.113		24.912	37.604	10.444			
Pesaran-Taylor reset statistic	0.627	0.014		0.141	0.058	0.000			
Pesaran-Taylor p-value	0.429	0.907		0.708	0.810	0.983			
Hansen-Sargan test statistic		2.231		2.283	0.351	4.816			
Hansen-Sargan p-value		0.135		0.131	0.554	0.028			
Ramsey reset F statistic			0.504				0.731	1.829	0.339
Probability > F			0.680				0.535	0.145	0.797

Robust standard errors in brackets

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

Table A7 Estimation path to preferred expenditure specifications for 2008/09

	(1) PBC 1 infectious 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 specification	(2) PBC 2 cancer 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 specification	(3) PBC 3 blood 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 specification	(4) PBC 4 endocrine 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 specification	(5) PBC 4 endocrine 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 revised	(6) PBC 4 endocrine 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 revised OLS	(7) PBC 5 mental health 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 specification	(8) PBC 6 LDisability 2008/09 spend SYLLR 2008/09/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 specification	(9) PBC 7 neurological 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 specification	(10) PBC 8 vision 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 specification
VARIABLES										
ILAgall_89netpopheadOHP	1.471*** [0.261]	0.784** [0.335]	0.995*** [0.272]	0.367 [0.244]	0.539*** [0.186]	0.498*** [0.147]	0.995*** [0.192]	0.329 [0.351]	0.897*** [0.204]	0.701*** [0.223]
ILAhivneedph	0.456*** [0.026]									
Ireal_LAallcausedsyllr890exlandP	-0.429** [0.214]									
ILAhivneedph2	0.181*** [0.023]									
Ireal_LAallcausedsyllr890excanc		-1.184*** [0.168]								
ILAneedCARAN		1.395*** [0.468]		0.721** [0.352]						
LPROFOCCU08		-0.348*** [0.094]						-0.516** [0.253]		
Ireal_LAallcausedsyllr890			-0.672** [0.265]				-0.303*** [0.112]	-0.460* [0.273]		-0.544** [0.213]
LLONEPARH08			0.535*** [0.152]							
Ireal_LAallcausedsyllr890exDIA				-0.177 [0.197]	0.054 [0.156]	0.097 [0.105]				
ILAneedCARAN2				1.666*** [0.460]				3.556** [1.393]		
ILAdiapiprevinover17				0.412*** [0.111]	0.290** [0.114]	0.285** [0.116]				
LNQUAL17408					1.210*** [0.391]	1.217*** [0.398]				0.664*** [0.079]
LNQUAL17408SQ					0.343*** [0.127]	0.347*** [0.129]				
ILAmhneedindexpp							0.658*** [0.143]			
LPOPPUCAR08							-0.618*** [0.104]			
Ireal_LAallcausedsyllr890exepi									-0.132 [0.152]	
ILAepilepsyov18prevrate									0.382*** [0.068]	

Constant	-5.190*** [1.130]	5.048* [2.695]	1.139 [1.594]	1.466 [2.244]	0.021 [0.980]	0.073 [0.976]	-1.644 [1.724]	3.663* [2.101]	-1.466 [0.992]	2.541** [1.057]
Observations	150	152	152	150	150	150	152	152	150	152
R-squared	0.783		0.194			0.579	0.789	0.104		
Ramsey reset F statistic	1.513		1.512			1.186	0.465	1.764		
Probability > F	0.214		0.214			0.317	0.707	0.157		
Endogeneity test statistic		19.732		1.423	0.174				8.533	4.237
Endogeneity p-value		0.000		0.233	0.677				0.003	0.040
Hansen-Sargan test statistic		1.028		0.014	0.335				0.081	0.592
Hansen-Sargan p-value		0.311		0.905	0.563				0.776	0.442
Kleibergen-Paap LM test statistic		36.285		33.925	33.244				32.990	34.619
Kleibergen-Paap p-value		0.000		0.000	0.000				0.000	0.000
Kleibergen-Paap F statistic		56.425		34.527	43.516				82.270	51.873
Pesaran-Taylor reset statistic		0.002		0.245	0.991				0.809	0.143
Pesaran-Taylor p-value		0.968		0.621	0.320				0.368	0.705

Robust standard errors in brackets

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

Table A7 continued Estimation path to preferred expenditure specifications for 2008/09

	(1) PBC 9 hearing 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 specification	(2) PBC 10 circulatory 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 specification	(3) PBC 10 circulatory 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 spec revised	(4) PBC 11 respiratory 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 specification	(5) PBC 12 dental 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 specification	(6) PBC 12 dental 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 08 re-derived	(7) PBC 12 dental 2008/9 spend SYLLR 2008/9/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 rederived OLS	(8) PBC 13 gastro 2008/9 spend SYLLR 2008/9/10 spend model instrument o/need weighted IV second stage GMM2S LA-level actual mortality actual census 08 09/10 specification	(9) PBC 14 skin problems 2008/09 spend SYLLR 2008/09/11 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 specification	(10) PBC 15 musculo-skeletal 2008/09 spend SYLLR 2008/09/10 spend model instrument n/a weighted OLS LA-level actual mortality actual census 08 09/10 specification
ILAgall_89netpopheadOHP	1.637*** [0.369]	0.614 [0.566]	1.784*** [0.276]	0.752** [0.352]	0.558*** [0.194]	0.373** [0.190]	0.428** [0.198]	0.520* [0.278]	0.907*** [0.199]	0.196 [0.316]
LOWNOCC08	0.377 [0.255]					0.286*** [0.108]	0.278** [0.110]			
Ireal_LAallcausedsyllr890	0.143 [0.320]				0.442*** [0.158]	0.322 [0.280]	0.279 [0.193]		0.001 [0.123]	0.260 [0.203]
Ireal_LAallcausedsyllr890excirc		-2.041*** [0.399]	-1.271*** [0.236]							
ILAneedCARAN		2.711*** [0.696]		1.987*** [0.418]				2.117*** [0.434]		0.947* [0.497]
LNQUAL17408			0.515*** [0.087]							
Ireal_LAallcausedsyllr890exresp				-1.099*** [0.285]						
ILAneedCARAN2				1.109** [0.530]						
LWORKAGRI08					-0.019 [0.019]					
LLONEPENH08					0.178 [0.144]					0.505*** [0.151]
ILAIMd_2007exexpobook						0.201* [0.119]	0.199* [0.111]		0.256** [0.108]	
Ireal_LAallcausedsyllr890exgast								-1.309*** [0.323]		
LHHNOCAR08									-0.222*** [0.074]	
LPC74LTUN08										-0.333*** [0.094]
Constant	-10.672*** [1.776]	12.261** [4.794]	-0.118 [1.402]	5.422* [2.892]	-2.382** [1.121]	-1.031 [1.528]	-1.183 [1.513]	8.403*** [2.751]	-4.278*** [1.256]	0.978 [2.832]
Observations	152	152	152	152	152	140	152	152	152	152
R-squared	0.256				0.477		0.501		0.495	0.510
Ramsey reset F statistic	0.130				3.630		3.756		1.203	1.928
Probability > F	0.942				0.015		0.012		0.311	0.128
Endogeneity test statistic		26.303	31.218	17.243		0.184		14.052		

Endogeneity p-value	0.000	0.000	0.000	0.668	0.000
Hansen-Sargan test statistic	0.401	0.278	0.097	1.329	0.009
Hansen-Sargan p-value	0.526	0.598	0.756	0.856	0.924
Kleibergen-Paap LM test statistic	24.836	28.178	34.175	22.399	32.639
Kleibergen-Paap p-value	0.000	0.000	0.000	0.000	0.000
Kleibergen-Paap F statistic	19.411	29.651	34.268	13.001	22.222
Pesaran-Taylor reset statistic	0.064	0.232	0.092	0.124	0.391
Pesaran-Taylor p-value	0.800	0.630	0.761	0.725	0.532

Robust standard errors in brackets

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

Table A7 continued Estimation path to preferred expenditure specifications for 2008/09

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	PBC 15	PBC 15	PBC 15	PBC 16	PBC 17	PBC 1819	PBC 20	PBC 21	PBC 22	PBC 23a
	musculo-skeletal	musculo-skeletal	musculo-skeletal	trauma	genito-	maternity	poisoning	HI	social care	GMS
	2008/9 spend	2008/9 spend	2008/9 spend	2008/9 spend	2008/9 spend	2008/9 spend	2008/9 spend	2008/9 spend	2008/9 spend	2008/9 spend
	SYLLR 2008/9/10	SYLLR 2008/9/10	SYLLR 2008/9/10	SYLLR 2008/9/10	SYLLR 2008/9/10	SYLLR 2008/9/10	SYLLR 2008/9/10	SYLLR 2008/9/10	SYLLR 2008/9/10	SYLLR 2008/9/10
	spend model	spend model	spend model	spend model	spend model	spend model	spend model	spend model	spend model	spend model
	instrument o/need	instrument o/need	instrument n/a	instrument n/a	instrument n/a	instrument o/need	instrument o/need	instrument n/a	instrument n/a	instrument n/a
	weighted	weighted	weighted	weighted	weighted	weighted	weighted	weighted	weighted	weighted
	IV second stage	IV second stage	OLS	OLS	OLS	IV second stage	IV second stage	OLS	OLS	OLS
	GMM2S	GMM2S				GMM2S	GMM2S			
	LA-level	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	real mortality	actual mortality	actual mortality	actual mortality
	actual census 08	actual census 08	actual census 08	actual census 08	actual census 08	actual census 08	actual census 08	actual census 08	actual census 08	actual census 08
VARIABLES	rederived	rederived+	re-derived+ OLS	09/10 specification	09/10 specification	09/10 specification	09/10 specification	09/10 specification	09/10 specification	09/10 specification
Ireal_LAsyllr890		0.392 [0.264]	0.271 [0.170]							
ILAgall_89netpopheadOHP	0.569*** [0.207]	0.641*** [0.240]	0.738*** [0.195]	1.344*** [0.222]	0.733*** [0.213]	0.963*** [0.339]	0.674* [0.366]	0.952 [0.699]	1.192* [0.605]	0.338*** [0.089]
LPC74LTUN08	-0.290*** [0.079]	-0.301*** [0.079]	-0.305*** [0.080]							
LPOPPUCAR08	0.916*** [0.125]	0.792*** [0.250]	0.681*** [0.224]							
LNQUAL17408		0.095 [0.166]	0.160 [0.152]							
Ireal_LAallcausedsyllr890	0.500*** [0.190]			-0.271 [0.170]		-0.299 [0.341]	-1.433*** [0.356]	0.076 [0.326]	-0.463 [0.410]	-0.028 [0.071]
LWORKAGRI08				0.084*** [0.018]						
LBORNEXEU08					0.037** [0.016]					
Ireal_LAallcausedsyllr890exrenal					-0.040 [0.130]					
ILANeedCARAN					0.251 [0.299]		2.102*** [0.546]	1.049 [0.809]		
ILAmatneedindexpp						0.809*** [0.135]				
Constant	-1.965 [1.563]	-2.043 [1.552]	-2.206 [1.617]	-3.653*** [0.989]	-0.747 [1.897]	-0.903 [0.819]	6.637* [3.581]	-3.945 [5.837]	-2.416 [3.223]	2.672*** [0.350]
Observations	152	152	152	152	152	152	152	152	106	150
R-squared			0.541	0.348	0.491			0.368	0.049	0.228
Endogeneity test statistic	0.671	0.197				1.649	19.393			
Endogeneity p-value	0.413	0.657				0.199	0.000			
Hansen-Sargan test statistic	2.561	2.323				2.648	0.006			
Hansen-Sargan p-value	0.464	0.313				0.266	0.936			
Kleibergen-Paap LM test statistic	37.710	32.836				15.039	33.275			
Kleibergen-Paap p-value	0.000	0.000				0.002	0.000			
Kleibergen-Paap F statistic	36.316	31.220				11.224	33.862			
Pesaran-Taylor reset statistic	0.089	0.118				0.215	0.029			
Pesaran-Taylor p-value	0.766	0.731				0.643	0.865			

Ramsey reset F statistic	1.296	0.793	1.741	0.317	0.331	0.753
Probability > F	0.278	0.500	0.161	0.813	0.803	0.522
Robust standard errors in brackets						
*** p<0.01, ** p<0.05, * p<0.1						

Note: lreal_LAallcausedsyllr890 is the same variable as lreal_LAsyllr890 (see 1, 2, 3) but name was changed so that Stata would reveal first-stage regression (Stata does not like long variable names).

Appendix 2: Expected health opportunity costs in the NHS (2008/09 results)

Overview

68. In the second appendix results are presented that reflect the available data for 2008/09 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 2008/09 compared to previously generated results

Year	2008/09	2009/10
Cost per QALY	£12,960	£9,887
Health opportunity costs of £10mn (QALYs)	772	1,011

72. It can be seen from Table A8 that the expected health opportunity costs of a given level of expenditure have decreased between 2009/10 and 2008/09 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 2008/09 compared to previously generated results

2008/09	Point estimate	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	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 2009/10 and 2008/09 and so the cost per QALY ratio has risen. In this table, the uncertainty associated with these estimates is shown and it can be judged to what extent any changes in the point estimate between years should be interpreted as a signal of any trend. 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 2008/09 and previously generated results – cost per QALY

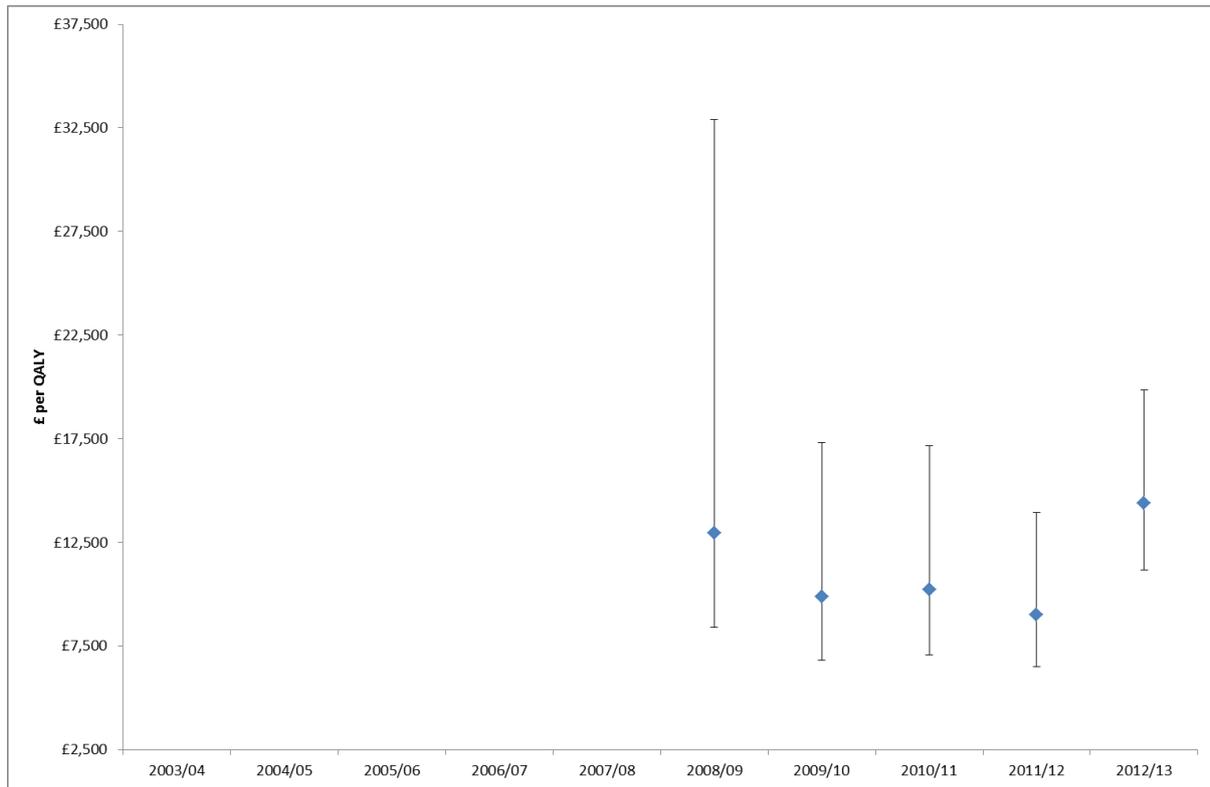
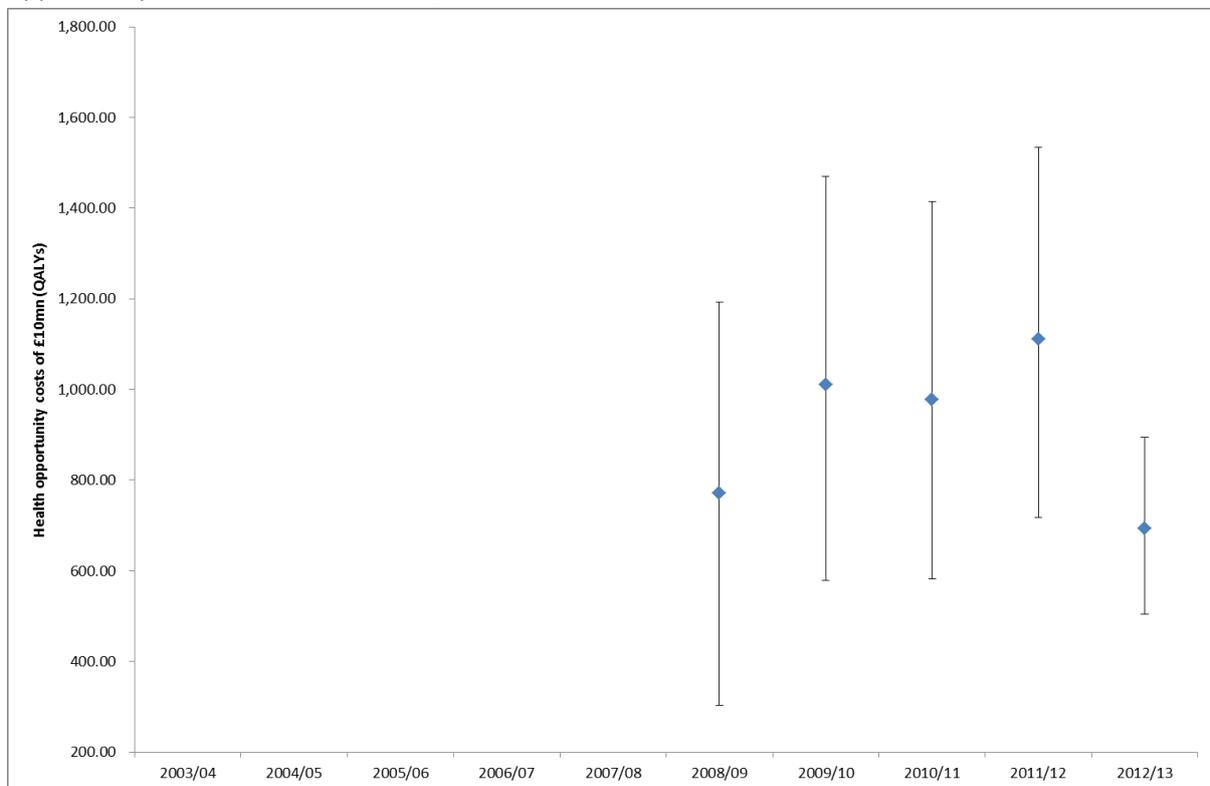


Figure A2 Results illustrating uncertainty for 2008/09 and previously generated results – Health opportunity costs of £10mn (QALYs)



70. 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).

71. 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 (£) 2008/09
2 Cancer	£ 17,594.59
10 Circulatory	£ 6,665.70
11 Respiratory	£ 2,151.60
13 Gastro-intestinal	£ 8,602.65
1 Infectious diseases	£ 19,030.88
4 Endocrine	£ 2,270.96
7 Neurological	£ 7,504.74
17 Genito-urinary	£ 2,978,823.26
16 Trauma & injuries*	N/A
18+19 Maternity & neonates*	£ 12,313,490.13
3 Disorders of Blood	£ 8,676.28
5 Mental Health	£ 17,250.44
6 Learning Disability	£ 137,944.35
8 Problems of Vision	£ 42,138.55
9 Problems of Hearing	£ 5,753.54
12 Dental problems	£ 39,088.10
14 Skin	£ 92,974.01
15 Musculo skeletal	£ 14,382.87
20 Poisoning and AE	£ 104,500.87
21 Healthy Individuals	£ 484,677.80
22 Social Care Needs	N/A
23 Other	N/A

72. 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

73. 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)
2 Cancer	£ 672,268.42	38	£ 17,594.59	31	4.01%	6
10 Circulatory	£ 723,546.46	109	£ 6,665.70	59	7.68%	4
11 Respiratory	£ 531,742.77	247	£ 2,151.60	182	23.63%	2
13 Gastro-intestinal	£ 367,309.53	43	£ 8,602.65	41	5.34%	5
1 Infectious diseases	£ 312,927.63	16	£ 19,030.88	14	1.83%	7
4 Endocrine	£ 144,398.76	64	£ 2,270.96	66	8.58%	3
7 Neurological	£ 550,260.43	73	£ 7,504.74	322	41.77%	1
17 Genito-urinary	£ 490,436.80	0	£ 2,978,823.26	13	1.73%	8
16 Trauma & injuries*	£ 774,506.00	0	N/A	-	-	-
18+19 Maternity & neonates*	£ 678,330.22	0	£ 12,313,490.13	0	0.05%	9
3 Disorders of Blood	£ 175,984.34	20	£ 8,676.28	-	-	-
5 Mental Health	£ 1,725,449.32	100	£ 17,250.44	-	-	-
6 Learning Disability	£ 167,421.92	1	£ 137,944.35	-	-	-
8 Problems of Vision	£ 209,507.56	5	£ 42,138.55	-	-	-
9 Problems of Hearing	£ 121,109.58	21	£ 5,753.54	-	-	-
12 Dental problems	£ 242,351.65	6	£ 39,088.10	-	-	-
14 Skin	£ 266,052.12	3	£ 92,974.01	-	-	-
15 Musculo skeletal	£ 332,394.07	23	£ 14,382.87	-	-	-
20 Poisoning and AE	£ 111,941.22	1	£ 104,500.87	-	-	-
21 Healthy Individuals	£ 308,557.23	1	£ 484,677.80	-	-	-
22 Social Care Needs	£ 395,495.64	0	N/A	-	-	-
23 Other	£ 698,008.34	0	N/A	-	-	-

Total:

772

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)
2 Cancer	£ 672,268.42	38	£ 17,594.59	14	1.85%	11
10 Circulatory	£ 723,546.46	109	£ 6,665.70	216	28.04%	2
11 Respiratory	£ 531,742.77	247	£ 2,151.60	228	29.50%	1
13 Gastro-intestinal	£ 367,309.53	43	£ 8,602.65	12	1.57%	13
1 Infectious diseases	£ 312,927.63	16	£ 19,030.88	6	0.72%	19
4 Endocrine	£ 144,398.76	64	£ 2,270.96	67	8.65%	3
7 Neurological	£ 550,260.43	73	£ 7,504.74	7	0.88%	18
17 Genito-urinary	£ 490,436.80	0	£ 2,978,823.26	32	4.11%	6
16 Trauma & injuries*	£ 774,506.00	0	N/A	29	3.76%	8
18+19 Maternity & neonates*	£ 678,330.22	0	£ 12,313,490.13	53	6.92%	4
3 Disorders of Blood	£ 175,984.34	20	£ 8,676.28	4	0.48%	22
5 Mental Health	£ 1,725,449.32	100	£ 17,250.44	13	1.66%	12
6 Learning Disability	£ 167,421.92	1	£ 137,944.35	25	3.24%	10
8 Problems of Vision	£ 209,507.56	5	£ 42,138.55	7	0.92%	17
9 Problems of Hearing	£ 121,109.58	21	£ 5,753.54	5	0.68%	20
12 Dental problems	£ 242,351.65	6	£ 39,088.10	12	1.50%	14
14 Skin	£ 266,052.12	3	£ 92,974.01	8	1.00%	16
15 Musculo skeletal	£ 332,394.07	23	£ 14,382.87	4	0.49%	21
20 Poisoning and AE	£ 111,941.22	1	£ 104,500.87	8	1.07%	15
21 Healthy Individuals	£ 308,557.23	1	£ 484,677.80	34	4.41%	5
22 Social Care Needs	£ 395,495.64	0	N/A	31	4.02%	7
23 Other	£ 698,008.34	0	N/A	28	3.68%	9

Total: 772

74. 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 PBCs 10 and 11 (circulatory and respiratory). Switching to look at Table A11 it can be seen that the most important PBCs in terms of outcome elasticity sensitivity are PBCs 7 and 11: neurological and respiratory.

75. 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)
2 Cancer	£ 672,268.42	35	3	-0.35%	14
10 Circulatory	£ 723,546.46	74	34	-4.42%	5
11 Respiratory	£ 531,742.77	12	235	-30.48%	1
13 Gastro-intestinal	£ 367,309.53	16	27	-3.46%	6
1 Infectious diseases	£ 312,927.63	4	13	-1.63%	10
4 Endocrine	£ 144,398.76	4	60	-7.79%	4
7 Neurological	£ 550,260.43	3	70	-9.12%	3
17 Genito-urinary	£ 490,436.80	0	0	-0.02%	18
16 Trauma & injuries*	£ 774,506.00	0	0	0.00%	-
18+19 Maternity & neonates*	£ 678,330.22	0	0	0.00%	19
3 Disorders of Blood	£ 175,984.34	1	19	-2.63%	9
5 Mental Health	£ 1,725,449.32	9	91	-12.96%	2
6 Learning Disability	£ 167,421.92	0	1	-0.16%	15
8 Problems of Vision	£ 209,507.56	0	5	-0.64%	12
9 Problems of Hearing	£ 121,109.58	0	21	-2.73%	8
12 Dental problems	£ 242,351.65	0	6	-0.80%	11
14 Skin	£ 266,052.12	1	2	-0.37%	13
15 Musculo skeletal	£ 332,394.07	1	22	-3.00%	7
20 Poisoning and AE	£ 111,941.22	0	1	-0.14%	16
21 Healthy Individuals	£ 308,557.23	0	1	-0.08%	17
22 Social Care Needs	£ 395,495.64	0	0	0.00%	-
23 Other	£ 698,008.34	0	0	0.00%	-
Total:		161	611		
Total change in QALY death + QALY alive			772		

76. 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 2008/09

77. 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 2008-2010 and 2009-2011 using LE for each PBC

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

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

Table A15 Estimated overall elasticities

	Elasticity comparable to all-cause model results
2009/10	0.94
2008/9	0.80