Methods for the Estimation of the NICE Cost Effectiveness Threshold

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Questions of fact and questions of value?

- When costs displace health (Δc_h)

$$\underbrace{\Delta h}_{\text{Health gained}} \quad \underbrace{-\frac{\Delta c_h}{k}}_{\text{Health forgone}} \geq 0 \qquad \left(v.\Delta h - \frac{v}{k}\Delta c_h \geq 0 \right)$$

- When costs displace consumption (Δc_c)

$$\Delta h \quad \underbrace{-\frac{\Delta c_c}{v}}_{\text{Consumption forgone}} \geq 0 \qquad \left(v.\Delta h - \Delta c_c \geq 0 \right)$$

- Costs fall on both

$$\Delta h \quad -\frac{\Delta c_h}{k} \quad -\frac{\Delta c_c}{v} \geq 0 \qquad \left(v.\Delta h - \frac{v}{k}\Delta c_h - \Delta c_c \geq 0 \right)$$

Fact : k = how much health **is** displaced by increased NHS costs?

Value: v = how much consumption **'should'** be given up for health?

What do we need?

- Need *k* what ever view of social value
- What its not
  - Consumption value of health (*v*)
  - Marginal productivity of ideal NHS
    - Dual of an MP solution with full information
- No simple relationship to changes in budget and prices
  - Changes in 'discretionary' expenditure (sensitive to overall change)
  - Changes in productivity
    - Stop doing things the NHS shouldn't do (increase *k*)
    - Improve those things it should do (reduce *k*)
- Heath production outside NHS
  - Complement, e.g., longer life expectancy (reduce *k*)
  - Substitute, e.g., reduced base line risk (increase *k*)

How can we estimate it?

- Informal judgement about the cost-effectiveness of things the NHS does and doesn't do
- Infer a threshold from past decisions

NICE threshold Range 2004 (2001)

- Find out what gets displaced and estimate its value

Appleby et al 2007

- Estimate the relationship between changes in expenditure and outcomes

Martin et al 2008, 2009

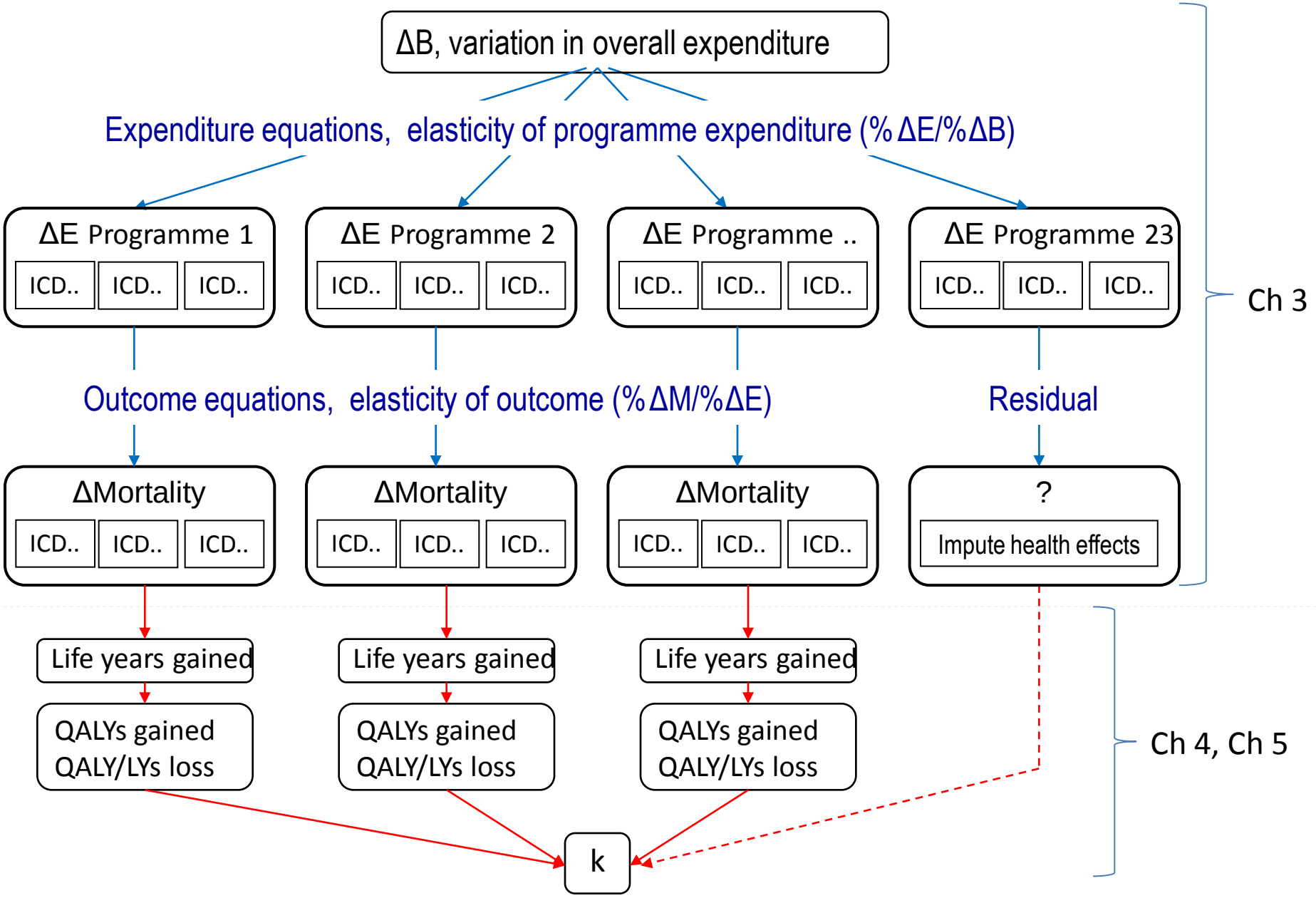
Relationship between expenditure and outcomes

- Martin et al (2008, 2009)
  - Variations in expenditure and outcomes within programmes
  - Reflects what actually happens in the NHS
  - Estimates the marginal productivity (on average) across the NHS

	Cancer	Circulation	Respiratory	Gastro-int
04/05 per LY	£13,137	£7,979		
05/06 per LY	£13,931	£8,426	£7,397	£18,999

- Need to estimate:
  - How changes in overall expenditure gets allocated across all the programmes
  - How changes in mortality might translate into QALYs gained
  - More (all) programmes

How can we estimate it?



Expenditure to mortality (Chapter 3)

- Builds on Martin et al (2008 and 2009)
  - Empirics founded on a simple theoretical model of PCT decisions
  - Addresses endogeneity in both the expenditure outcome equations
- Developed in a number of ways
  - Change in PBC expenditure due to change in overall expenditure (all 23 PBCs)
    - PBC spend in part determined by other PBC need but it also influences other PBC need
    - Instrument that predicts the proxi for other PBC need but unrelated to PBC spend
  - Change in PBC mortality outcomes due to change in PBC expenditure (11 PBCs)
    - PBC outcomes are in part determined by PBC spend but outcomes influence PBC spend
    - Instrument that predicts PBC spend but is unrelated to PBC outcome
  - Structural uncertainty in instrumental validity (Conley, Hansen and Rossi 2012)
  - Correlation between expenditure and outcome elasticities
  - Outcome data lags expenditure (average over spend and 2 subsequent years)
  - Updated measures of PBC need and environment (MFFs)
  - 151 observations in the cross section (each PBC separately)
  - Estimates for 3 waves of expenditure data (2006, 2007, 2008)

Mortality to life years (YLL) (Section 4.2)

- Issues
  - What is available by PCT (SMR and SYLL only for some ICDs)
  - How best to adjust
    - What should we apply the estimates of % effect of expenditure to
  - How to calculate YLL (NHS IC, WHO etc)
    - Fixed LE?
      - 75 years?
      - LE of general population
      - LE of the age and gender distribution of PBC
    - Problem – counterfactual deaths
      - Net YLL
        - » Account for all deaths above and below LE
        - » Same as area between survival curves

Mortality to life years (YLL) (Section 4.2)

Table 4.5. Net YLL using life expectancy for each PBC

PBC		LE of Males [1]	LE of Females [2]	Average2006-2008 Deaths <LE [3]	Deaths >LE [4]	YLL [5]	YLG [6]	Net YLL [7]
1	Infectious diseases	79.6	83.6	3,498	3,460	58,686	21,724	36,962
2	Cancer	83.0	84.7	101,203	29,607	1,473,733	126,549	1,347,184
4	Endocrine	81.0	84.7	4,068	2,696	66,283	15,058	51,225
7	Neurological	79.6	83.3	8,370	6,983	135,686	41,770	93,917
10	Circulatory	83.0	86.5	96,694	63,157	1,102,020	278,251	823,768
11	Respiratory	80.3	84.0	29,549	35,897	298,343	230,313	68,030
13	Gastro-intestinal	80.6	84.5	15,824	8,323	273,117	45,414	227,703
17	Genito-urinary	83.5	85.6	4,969	5,655	47,229	29,101	18,127
18+19	Maternity & neonates	78.7	83.1	226	0	16,801	0	16,801

Mortality to life years (YLL) (Section 4.2)

Table 4.6. Summary of cost per life year threshold

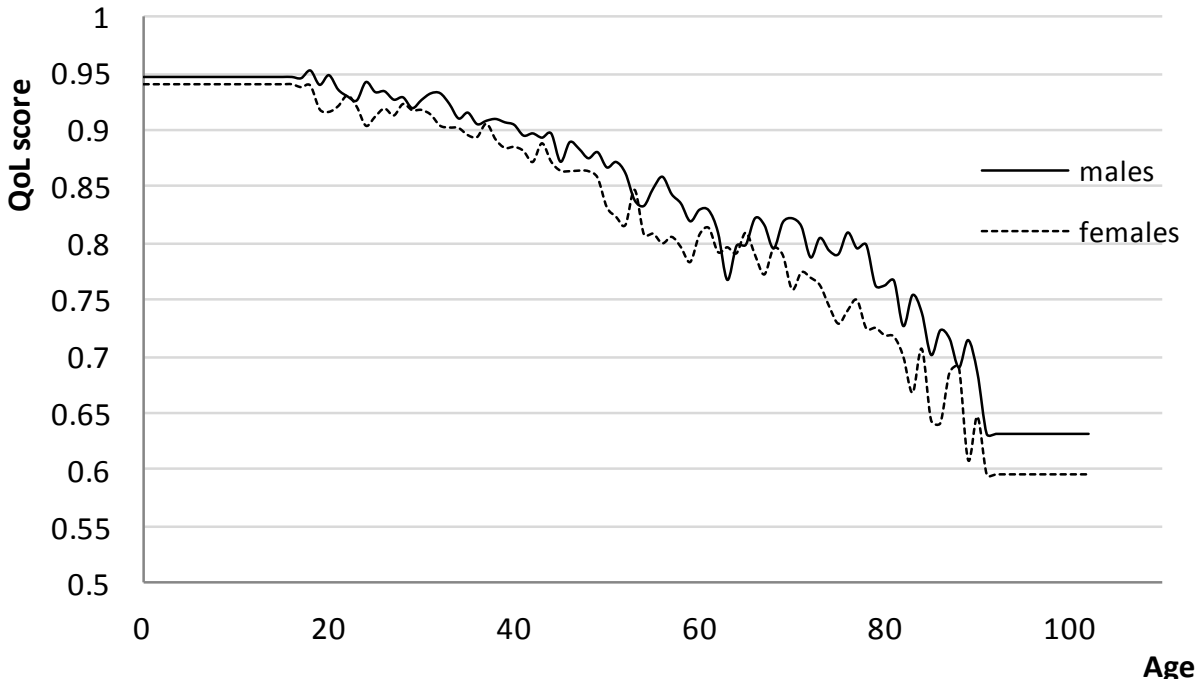
	Using cut-off in estimating YLL (ONS)		Using net YLL estimates	
	cut-off of 75	cut-off of LE of the GP	Using LE of the GP	Using LE of the PBC population (GBD)
	[1]	[2]	[3]	[4]
big 4 PBC's	£10,398	£5,487	£10,421	£8,080
11 PBCs (with mortality)	£20,031	£10,660	£19,928	**£15,628**
All 23 PBCs (zero health effects for remaining 12 PBCs)	£73,697	£39,218	£73,317	£57,497
All 23 PBCs (non-zero health effects for remaining 12 PBCs, except GMS)*	£22,639	£12,048	£22,523	**£17,663**

* in PBCs without a mortality signal, health effects were estimated by valuing changes in expenditure at the same rate as observed in PBCs for which there was a mortality signal except GMS.

Adjusting life year effects for quality (Section 4.3)

- Issues
  - Adjust before calc Net YLL adjusted for quality
    - Reflect QoI norms by age and gender (HoDAR)
    - Disease decrements by ICD code (HoDAR & MEPS)
  - Solved with QoI burden in 4.4

Figure 1: Quality of life for the general population by age and gender



Adjusting life year effects for quality (Section 4.3)

Table 4.14: Summary of QALY threshold estimates based only on mortality effects

	[1] *(QoL score =1)*	[2] *(QoL norm)*	[3] *(QoL diseased)*	
		Best estimate		
Effect of expenditure on mortality:	*1 year*	*1 year*	*1 year*	
YLL per death averted:	*~4.1YLL ***	*~4.1YLL ***	*~4.1YLL ***	
QALYs per death averted	*~4.1QALYs*	*~3.5QALYs*	*~2.8QALYs*	
big 4 PBC's	£8,080	£9,631	£12,109	[1]
11 PBCs (with mortality)	£15,628	£18,622	£23,395	[2]
All 23 PBCs*	£17,663	**£21,047**	£26,441	[3]

Table 4.14: Summary of QALY threshold estimates based only on mortality effects
* in PBCs without a mortality signal, health effects were estimated by valuing changes in expenditure at the same rate as observed in PBCs for which there was a mortality signal except GMS.
** see Tables 14, 15 and 18 in Appendix C

Effects on quality and length of life (Section 4.4)

- Issues
  - Mortality is irrelevant or not a primary concern for many PBCs
  - Much NHS activity is primarily to improve quality of life
  - Cant observe quality effects by PBC and PCT
- Responses
  - Use what can observe to impute what cant
    - Have estimates of % effect on YLL burden of disease
    - Apply % effect to measures of QALY burden (by ICD via u-code)
    - Sum QALY effects over ICDs that contribute to each PBC
- Requires
  - Incidence by age and gender and duration (by u-code, GBD)
  - QoI from HoAR and MEPS
  - Allocation to ICD (weights for the average)
    - Contribution to variance in PBC costs (HES)
    - Size of the population at risk in ICD code
  - Proportionate effect in 11 PBCs applied to estimates of burden in the other 12
  - Uses all the information we have about the other 11 PBCs
  - Disease decrement during duration and norms if LY gained beyond

Effects on quality and length of life (Section 4.4)

Table 4:20: Summary of cost per QALY threshold estimates

	[1]	[2]	[3]	
QoL associated with life extension:	*1*	*Norm*	*norm*	
QoL during disease:	*0*	*0*	*Based on burden*	
			Best estimate	
Effect of expenditure on mortality:	*1 year*	*1 year*	*1 year*	
YLL per death averted:	*~ 4.1 YLL*	*~ 4.1 YLL*	*~ 4.1 YLL*	
QALYs per death averted:	*~ 4.1 QALY*	*~ 3.5 QALY*[1]	*~ 12.6 QALY*	
big 4 PBC's	£8,080	£9,631	£3,036	[1]
11 PBCs (with mortality)	£15,628	£18,622	£5,128	[2]
All 23 PBCs	£17,663	£21,047	**£15,701**	[3]

Effects on quality and length of life (Section 4.4)

Table 4:20: Summary of cost per QALY threshold estimates

Effect of expenditure on mortality: *YLL per death averted:* *QALYs per death averted:*	*Remainder of disease duration* *~ 4.1 YLL* *~ 4.1 QALY*	*Remainder of disease duration* *~ 4.1 YLL* *~ 3.5 QALY*	**Lower bound** *Remainder of disease duration* *~ 4.1 YLL* *~ 12.6 QALY*	
big 4 PBC's	£3,846	£4,252	£674	[4]
11 PBCs (with mortality)	£6,106	£6,852	£860	[5]
All 23 PBCs	£6,901	£7,744	**£2,785**	[6]
Effect of expenditure on mortality: *YLL per death averted:* *QALYs per death averted:*	*1 year* *2 YLL* *~ 2 QALY*	*1 year* *2 YLL* *~ 1.9 QALY*	**Upper bound** *1 year* *2 YLL* *~ 6.1 QALY*	
big 4 PBC's	£16,432	£17,456	£6,292	[7]
11 PBCs (with mortality)	£32,387	£34,492	£10,626	[8]
All 23 PBCs	£36,604	£38,983	**£32,537**	[9]

Implications for a policy threshold (Section 5.2)

Table 4:21: Summary of cost per QALY threshold estimates (2008)

	[1]	[2]	[3]	
QoL associated with life extension:	*1*	*Norm*	*norm*	
QoL during disease:	*0*	*0*	*Based on burden*	
			Best estimate	
Effect of expenditure on mortality:	*1 year*	*1 year*	*1 year*	
YLL per death averted:	*~ 4.5 YLL*	*~ 4.5 YLL*	*~ 4.6 YLL*	
QALYs per death averted:	*~ 4.5 QALY*	*~ 3.8 QALY*	*~ 12.7 QALY*	
big 4 PBC's	£10,220	£12,338	£4,872	[1]
11 PBCs (with mortality)	£23,360	£28,045	£8,308	[2]
All 23 PBCs	£25,214	£30,270	**£18,317**	[3]

Table 4:22: Impact of each PBC on the overall cost per QALY threshold (2008)

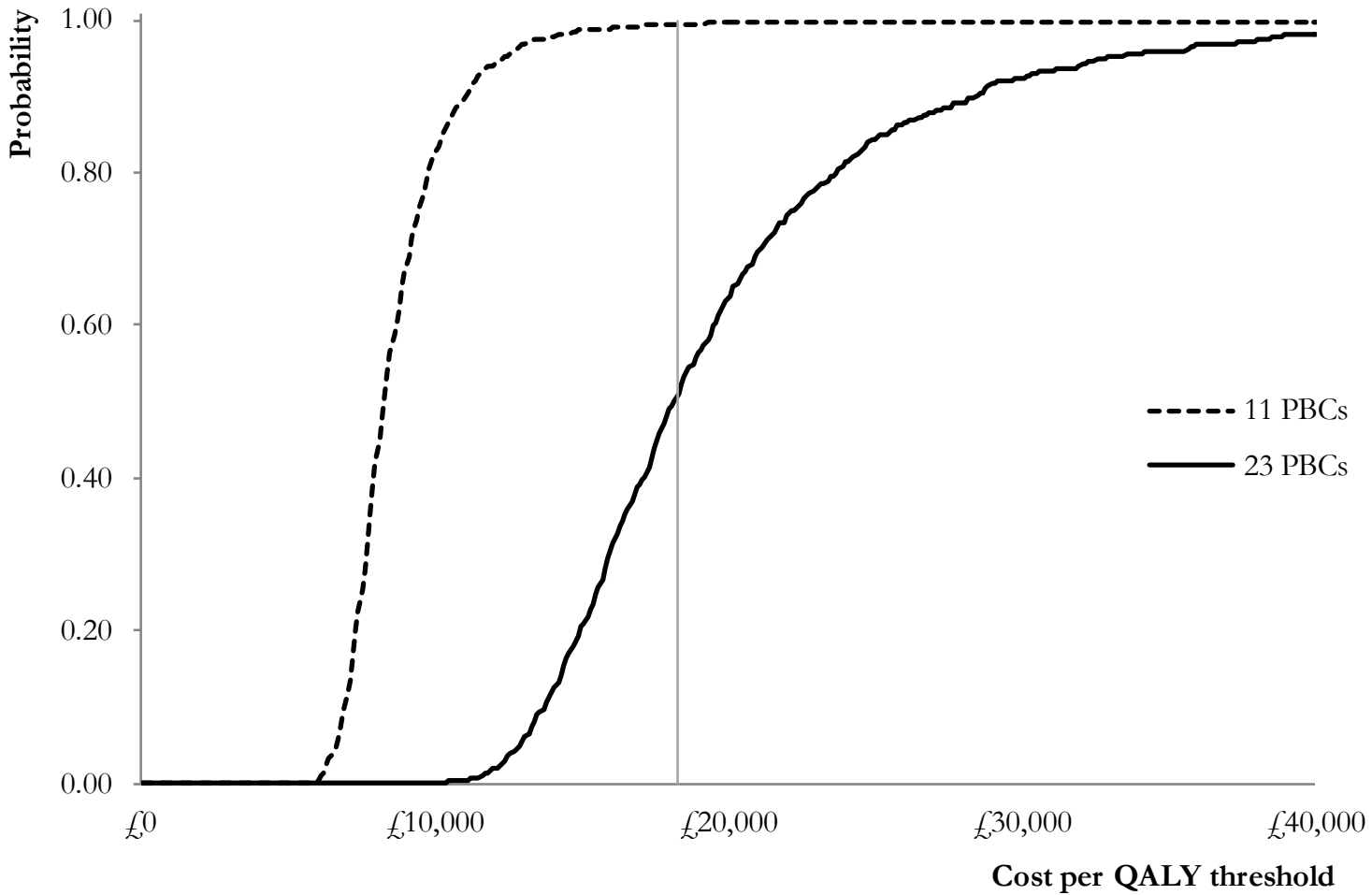
Which PBCs matter most? (Section 5.3)

	PBC	% spend	% health	Elasticity	PBC cost per QoI
2	Cancer	3.24	3.50	0.35	£16,997
10	Circulatory	5.50	14.32	1.43	£7,038
11	Respiratory	3.32	30.45	3.05	£1,998
13	Gastro-intestinal	2.32	5.83	0.58	£7,293
1	Infectious diseases	2.37	2.08	0.21	£20,829
4	Endocrine	1.37	8.04	0.80	£3,124
7	Neurological	4.33	14.48	1.45	£5,480
17	Genito-urinary	3.36	1.40	0.14	£43,813
16	Trauma & injuries*	5.58	0	0	NA
18+19	Maternity & neonates*	4.95	0.03	0.00	£2,969,208
3	Disorders of Blood	2.92	1.89	0.19	£28,305
5	Mental Health	**25.32**	**9.31**	0.93	**£49,835**
6	Learning Disability	1.47	0.34	0.03	£78,854
8	Problems of Vision	2.75	0.66	0.07	£76,850
9	Problems of Hearing	1.24	1.19	0.12	£19,070
12	Dental problems	4.09	1.34	0.13	£55,916
14	Skin	2.79	0.29	0.03	£174,775
15	Musculo skeletal	5.14	4.65	0.47	£20,254
20	Poisoning and AE	1.32	0.15	0.01	£163,766
21	Healthy Individuals	5.01	0.06	0.01	£1,483,012
22	Social Care Needs	4.26	0	0	NA
23	Other	7.35	0	0	NA

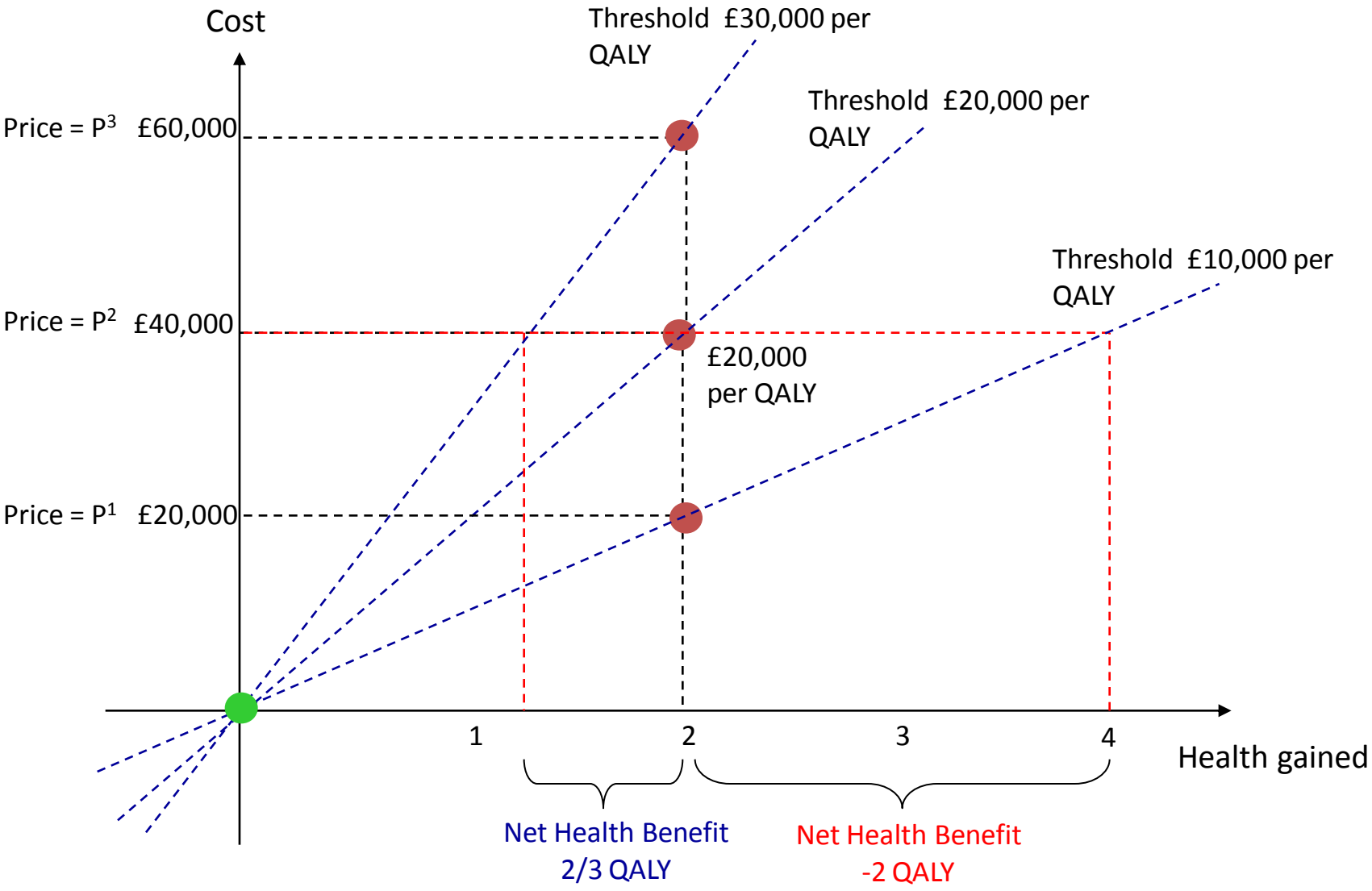
How uncertain are the estimates? (Section 5.4)

An assessment of parameter uncertainty

Figure 4.3 Cumulative probability density function for the cost per QALY threshold



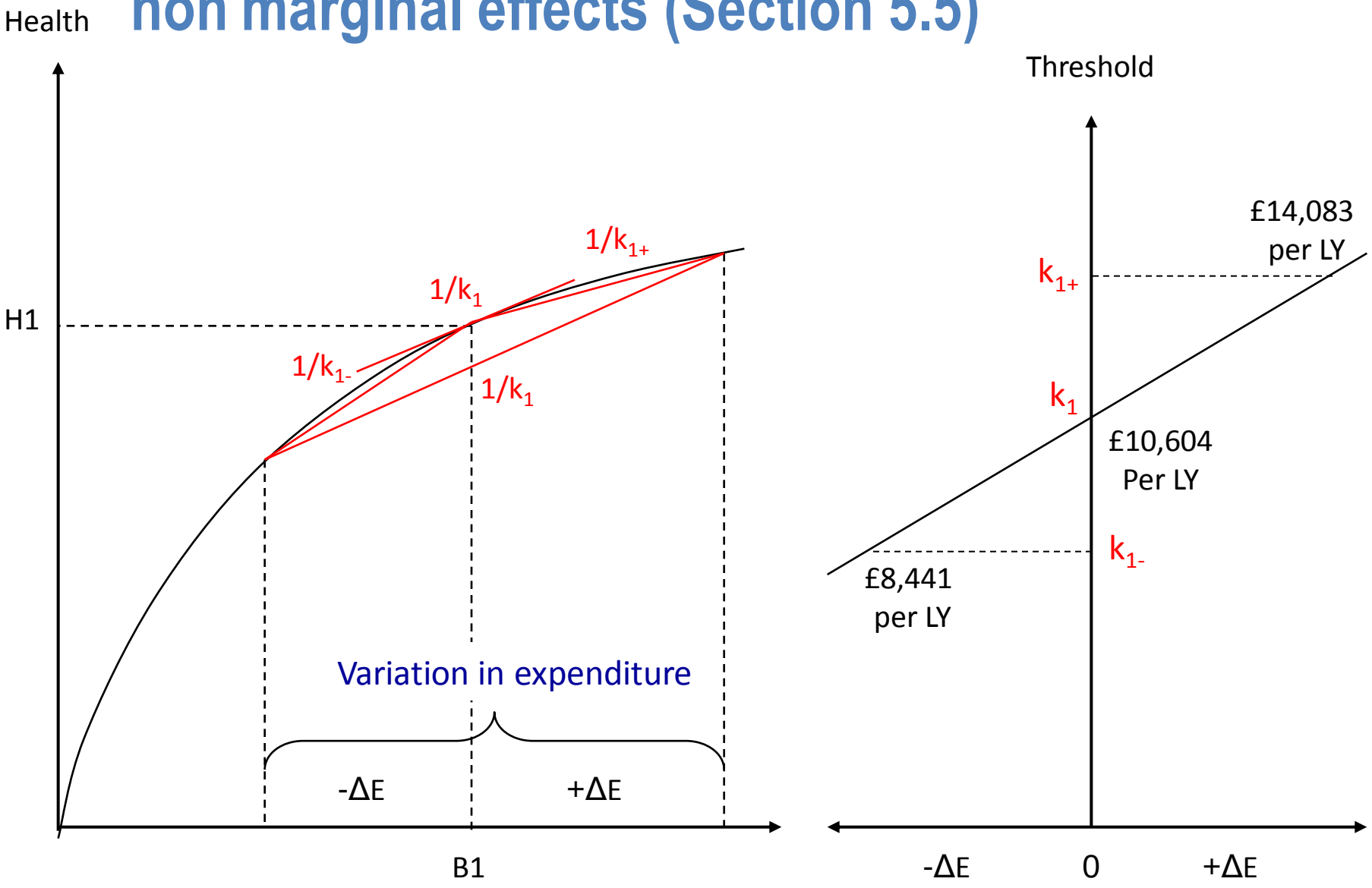
Implications for a policy threshold? (Section 5.4)



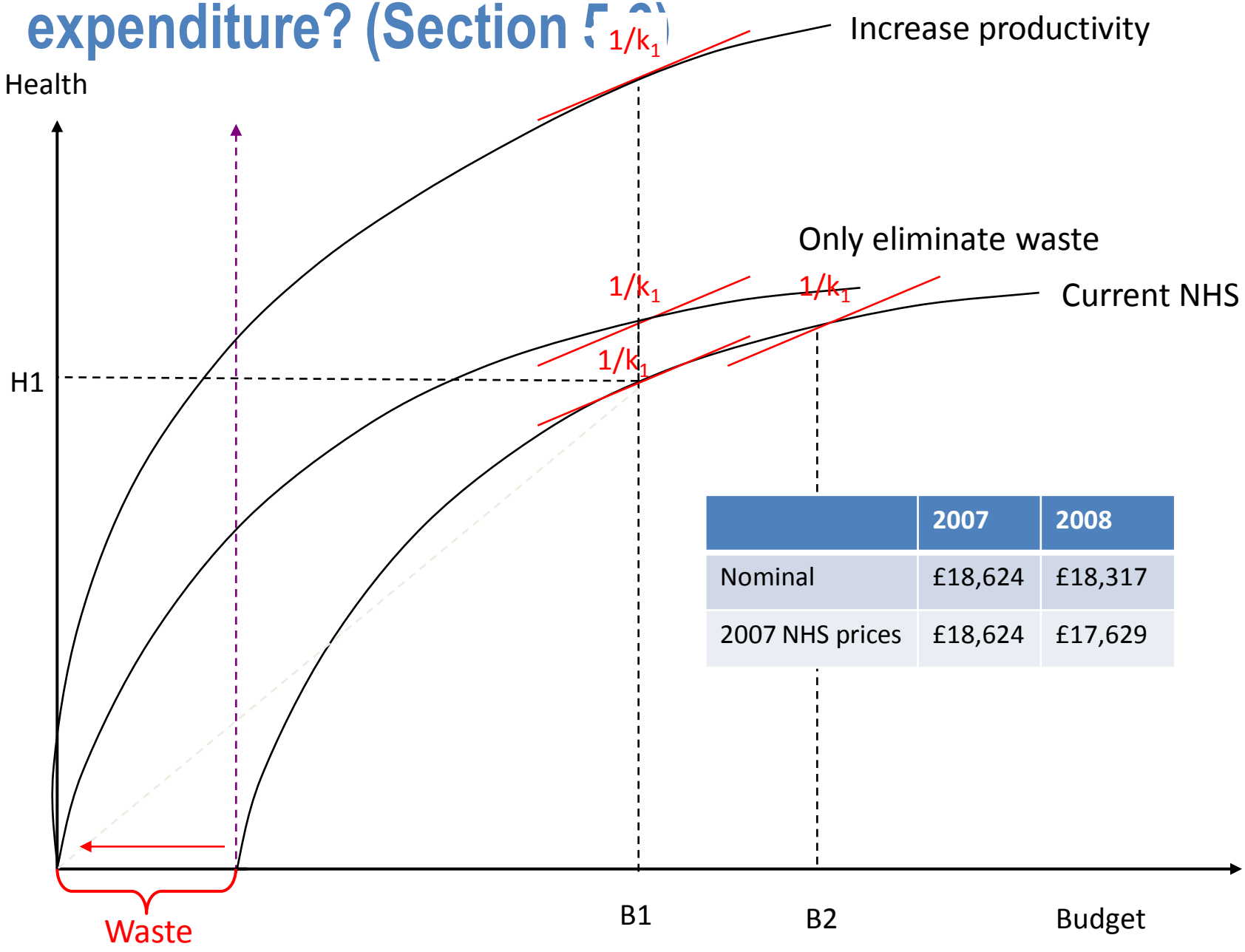
Other sources of uncertainty (Section 5.4)

- Structural uncertainty (validity of instruments)
  - Point estimates are robust
  - Increase uncertainty dramatically (reduce the policy threshold)
- Heath effects over estimated (threshold underestimated)?
  - Deaths averted by a change in expenditure returns the individuals to the mortality risk of the general population (matched for age and gender)
  - Small positive correlation between expenditure and outcome elasticities tends to increase the expected value of threshold.
- Heath effects under estimated (threshold overestimated)?
  - Quality of life effects restricted to one year
    - long term effects on quality of life, e.g., hip replacement etc
  - Mortality effects restricted to one year
    - Reduce risk throughout their disease duration
  - changes in expenditure reduce incidence into the at risk population (prevention)
  - Imputed cost per QALY in mental health likely to be too high

Impact of investment, disinvestment and non marginal effects (Section 5.5)



How does the threshold change with overall expenditure? (Section 5.2)



	2007	2008
Nominal	£18,624	£18,317
2007 NHS prices	£18,624	£17,629

Table 5.4 Heath forgone across PBCs due to the approval of Ranibizumab (Lucentis) (£80m budget impact)

What type of is health lost (Section 5.7)

	PBC	Spend £m	Deaths	Life years	QALYs	QALYs (death)	QALYs (Qol)
2	Cancer	£2.59	22	217	153	141	11
10	Circulatory problems	£4.40	132	672	625	427	198
11	Respiratory problems	£2.66	78	93	1,330	58	1,272
13	Gastro-intestinal	£1.86	15	143	255	94	161
1	Infectious diseases	£1.89	4	31	91	21	70
4	Endocrine problems	£1.10	4	29	351	19	332
7	Neurological problems	£3.47	7	38	632	25	608
17	Genito-urinary problems	£2.69	13	19	61	12	49
16	Trauma & injuries	£4.46	0	0	0	0	0
18+19	Maternity & neonates	£3.96	0	2	1	1	0
3	Disorders of Blood	£2.33	1	6	82	4	78
5	Mental Health Disorders	£20.25	12	55	406	35	371
6	Learning Disability	£1.18	1	4	15	3	12
8	Problems of Vision	£2.20	0	2	29	1	28
9	Problems of Hearing	£0.99	0	1	52	0	52
12	Dental problems	£3.27	0	0	59	0	59
14	Skin	£2.23	2	7	13	5	8
15	Musculo skeletal system	£4.11	3	15	203	10	193
20	Poisoning and AE	£1.05	0	2	6	1	5
21	Healthy Individuals	£4.01	0	1	3	0	2
22	Social Care Needs	£3.41	0	0	0	0	0
23	Other	£5.88	0	0	0	0	0
	All (23 PBCs)	**£80**	**295**	**1337**	**4367**	**859**	**3509**

Future research and improving estimates of the threshold (Section 5.8)

- Longer and more complex lag structure
  - Duration of effect on mortality might be feasible
  - Estimating life year effect of mortality more problematic
- Simultaneous estimation across PBCs
- Exogenous shocks and quasi experiments
- Evolving PBC data
- Extending measures of health outcome
  - Analysis of PROMs data
  - IAPT and mental health outcomes
- Incidence and duration of disease
  - WHO GBD
  - GPRD

Implications for value based pricing?

- Have estimated the 'Basic' threshold
- Scientific question of fact
  - Repeatable, accountable and predictable
- Other aspect of social value?
  - Type of QALYs (e.g., burden of disease)
    - Apply weights to QALYs forgone
    - Threshold for weighted QALYs or adjust the basic threshold
  - Consumption and other public expenditure effects (WSB)
    - Related to QALY effects or characteristics associated with ICD (age, gender)
    - Estimate both QALY and the WSB forgone
    - Given a value for v express as QALY or consumption equivalent