Methods for the Estimation of the NICE Cost Effectiveness Threshold

Karl Claxton,[1,2] Steve Martin,[2] Marta Soares,[1] Nigel Rice,[1,2] Eldon Spackman,[1] Sebastian Hinde,[1] Nancy Devlin,[3] Peter C Smith,[4] Mark Sculpher[1]

1. Centre for Health Economics, University of York, UK
2. Department of Economics and Related Studies, University of York, UK
3. Office of Health Economics, London, UK
4. Imperial College, London, UK

What do we need?

- Compare
  - Health *expected* to be gained
  - Health *expected* to be lost due to additional NHS costs
- Expected health effects of changes in NHS expenditure
- What its not
  - Consumption value of health (willingness to pay)
  - Marginal productivity of 'ideal' NHS
- No simple relationship with changes in
  - Budget, prices and productivity
  - Health production outside NHS

How can we estimate it?

- Implied value from past decisions based on informal judgements

NICE threshold Range 2004 (2001)

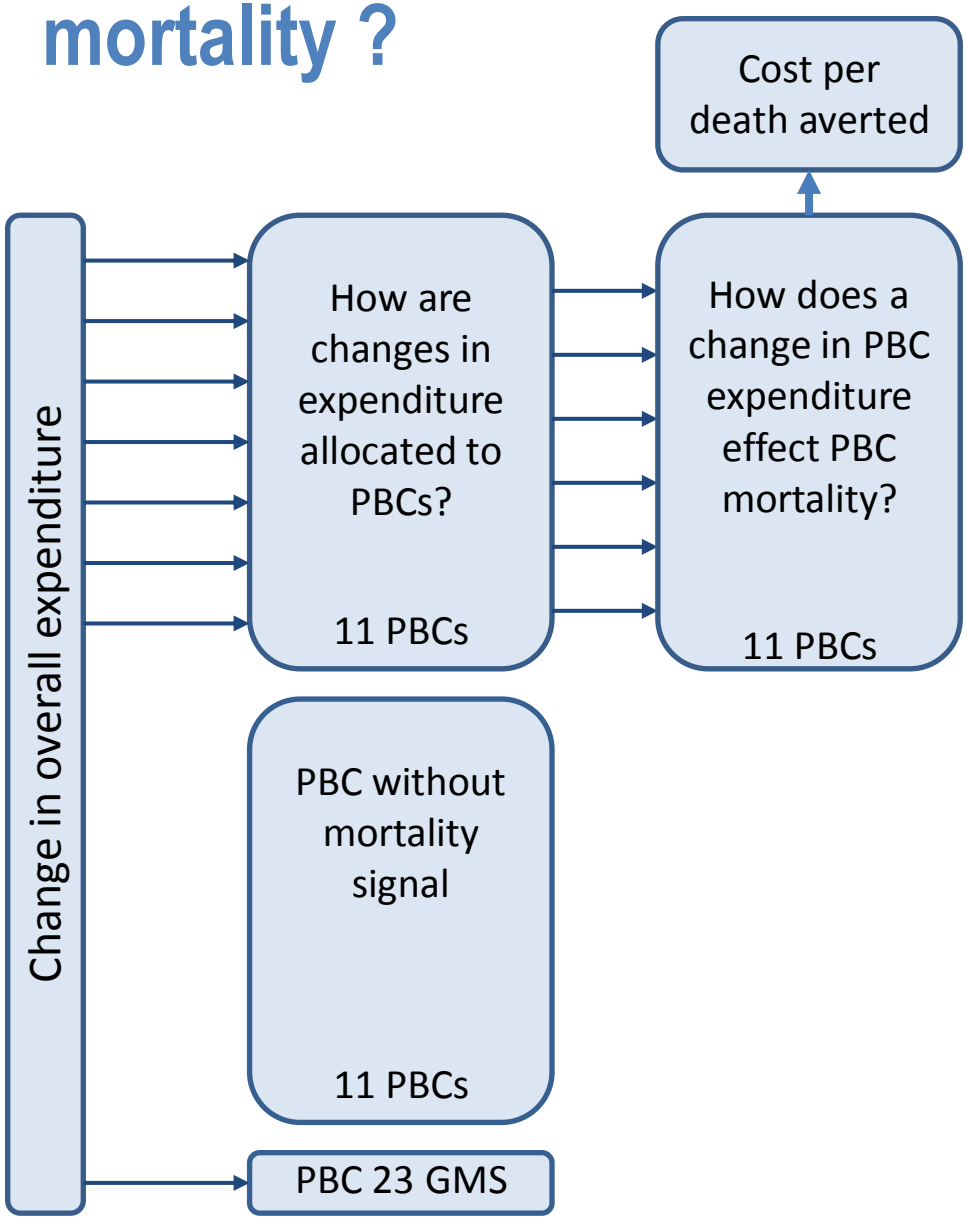
- Find out what decisions are made and estimate impact on cost and health
  - Which/ whose decisions?
  - Caused by NICE guidance?
  - Effect of decisions on health and costs?
  - But we don't need to know which decisions just the health effects

Appleby et al 2007

- Estimate the relationship between changes in expenditure and outcomes

Martin et al 2008, 2009

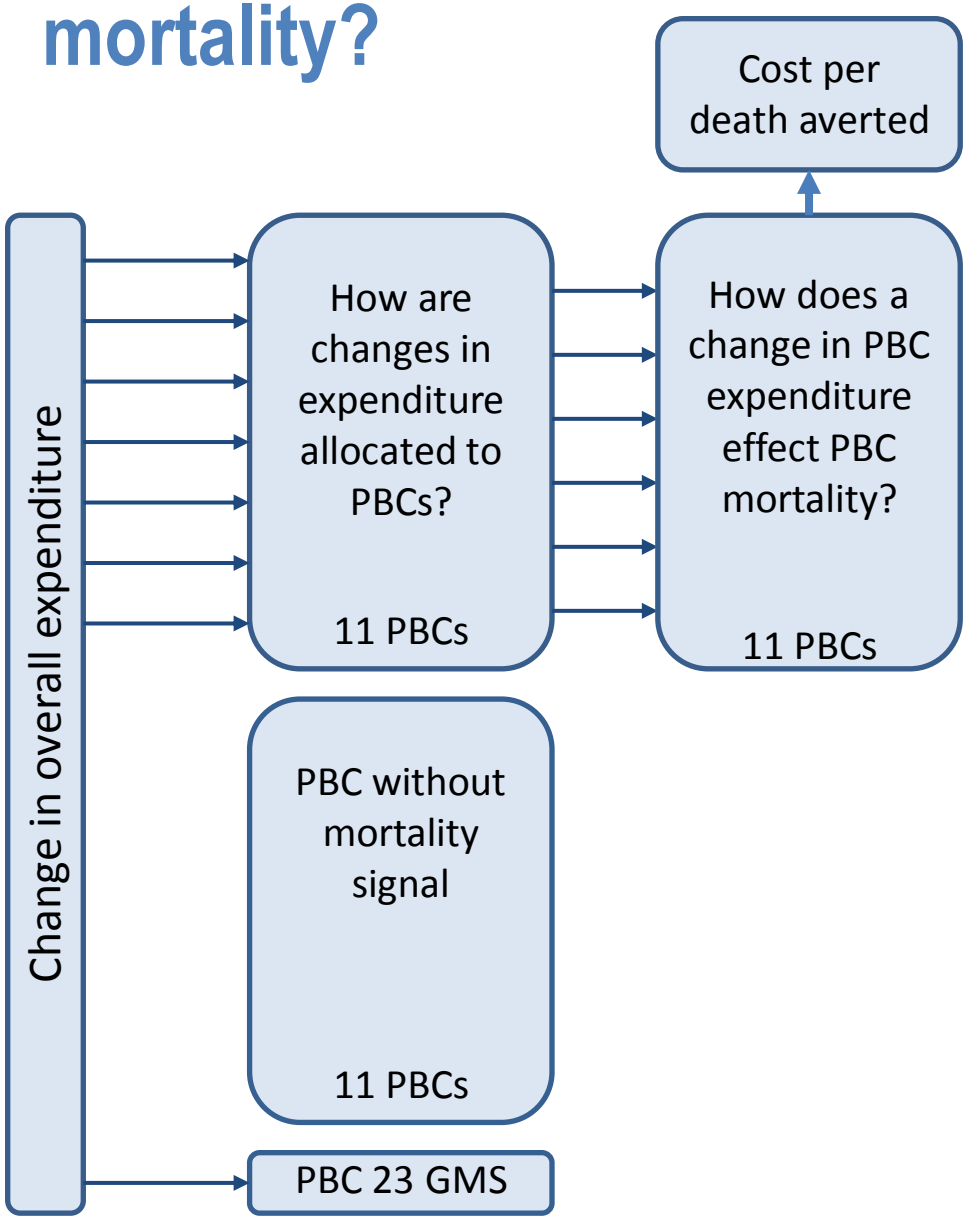
How can we estimate effects of expenditure on mortality ?



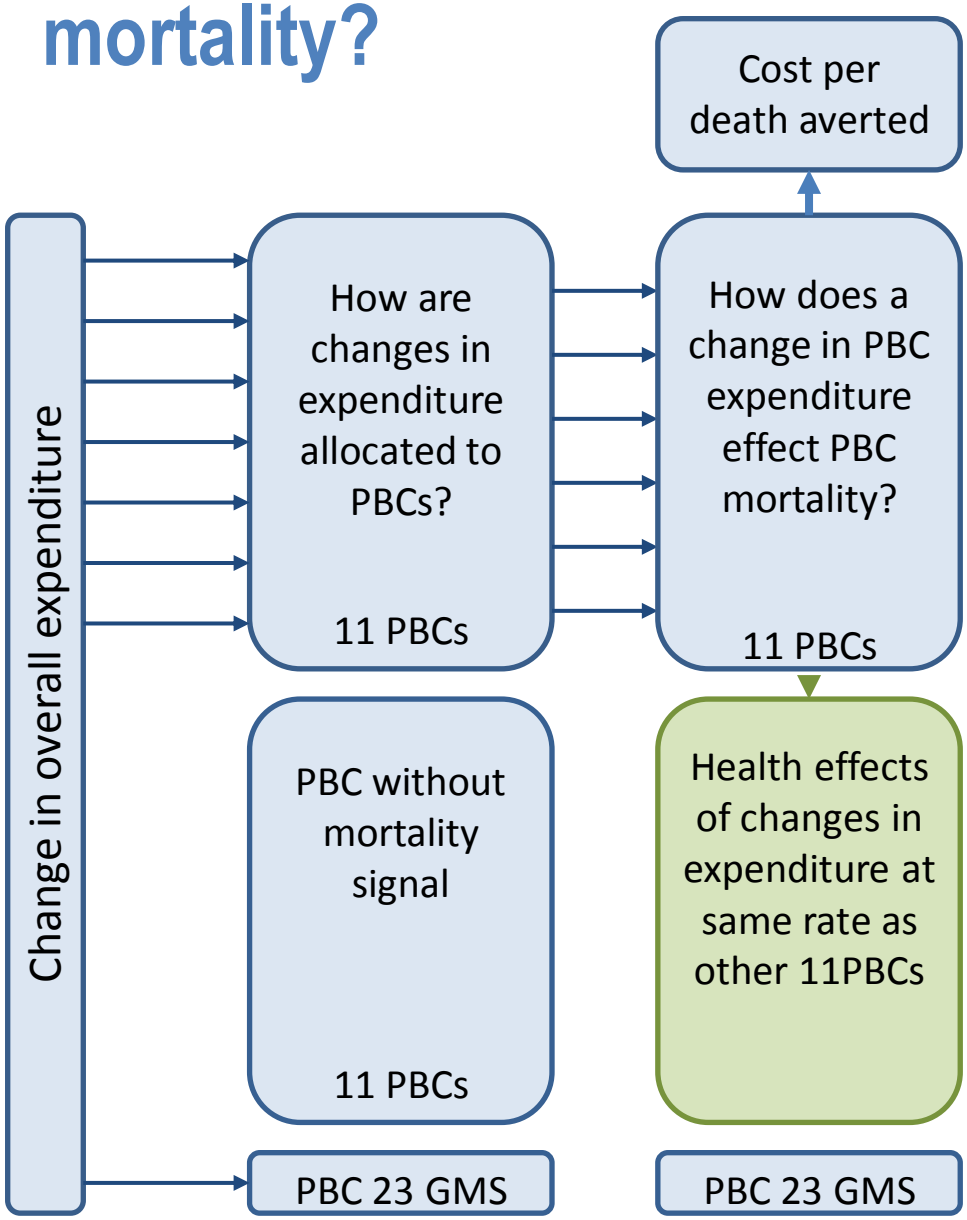
How can we estimate effects of expenditure on mortality (deaths)?

- Change in PBC expenditure due to change in overall expenditure (all 23 PBCs)
  - Differences in spending on a particular PBC and total spend across PCTs
  - Account for other reasons why PBC spend might differ between PCTs
  - Isolate the effects on PBC spend of changes in overall expenditure
- Change in PBC mortality (deaths) due to change in PBC expenditure (11 PBCs)
  - Differences in PBC mortality and PBC expenditure across PCTs
  - Account for other reasons why PBC mortality might differ between PCTs
  - Isolate the effects on PBC mortality of changes in PBC expenditure

How can we estimate effects of expenditure on mortality?



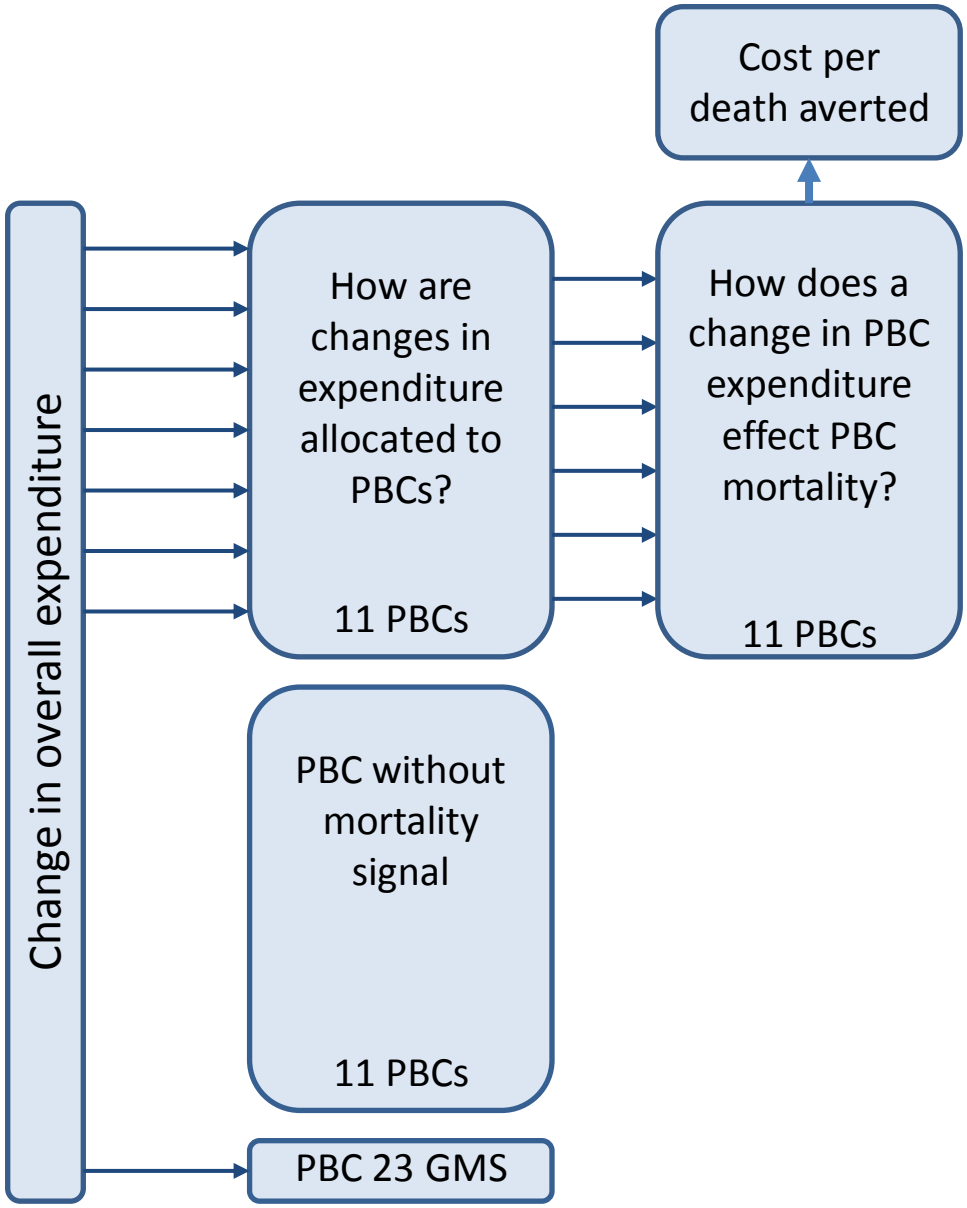
How can we estimate effects of expenditure on mortality?



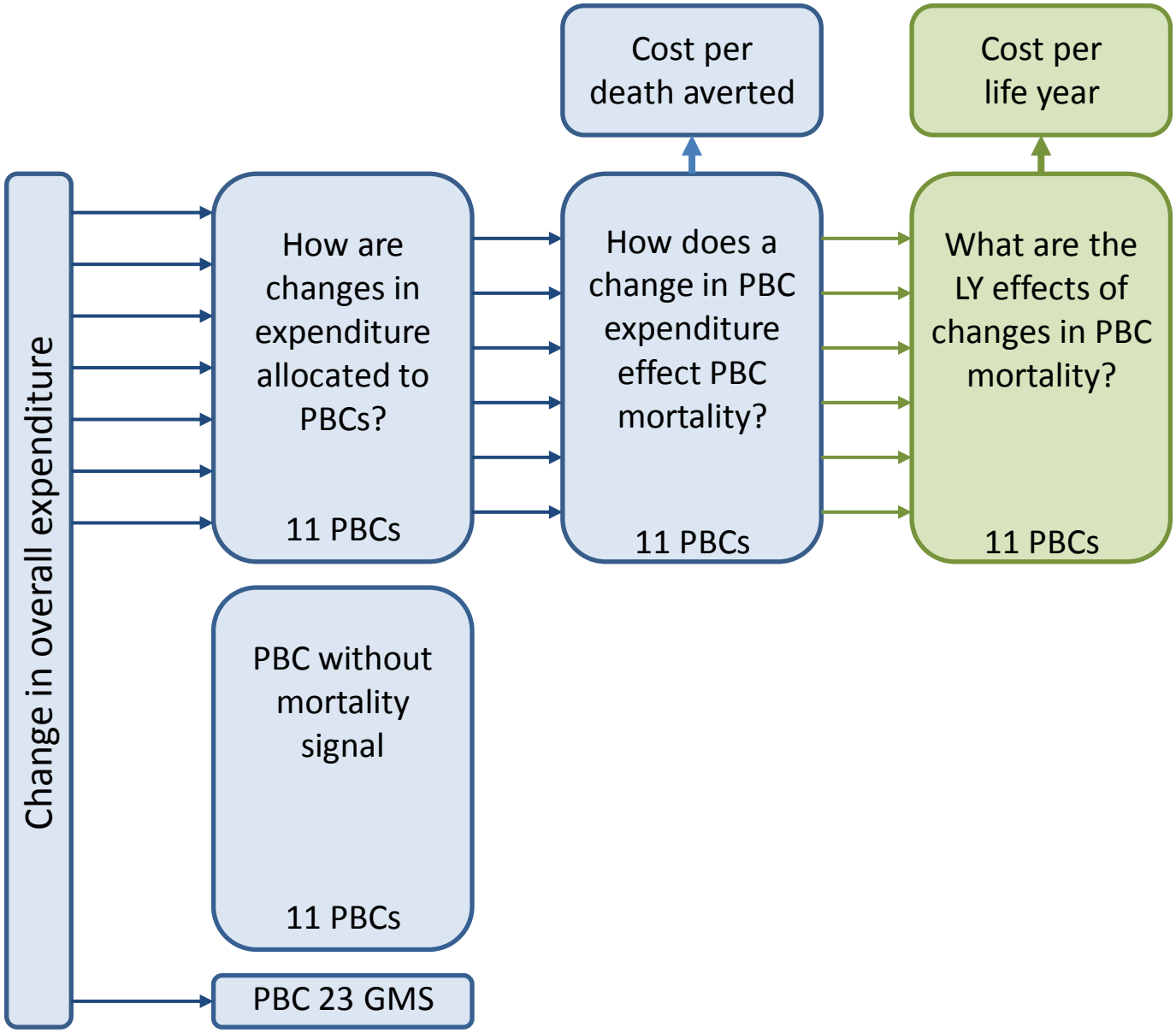
Estimates of the threshold (2008-09)

	Cost per death averted
Qol associated with LYs	-
Qol during disease	-
YLL per death averted	-
QALYs per death averted	-
11 PBCs (with mortality)	£105,872
All 23 PBCs	£114,272

How can we estimate effects on life years



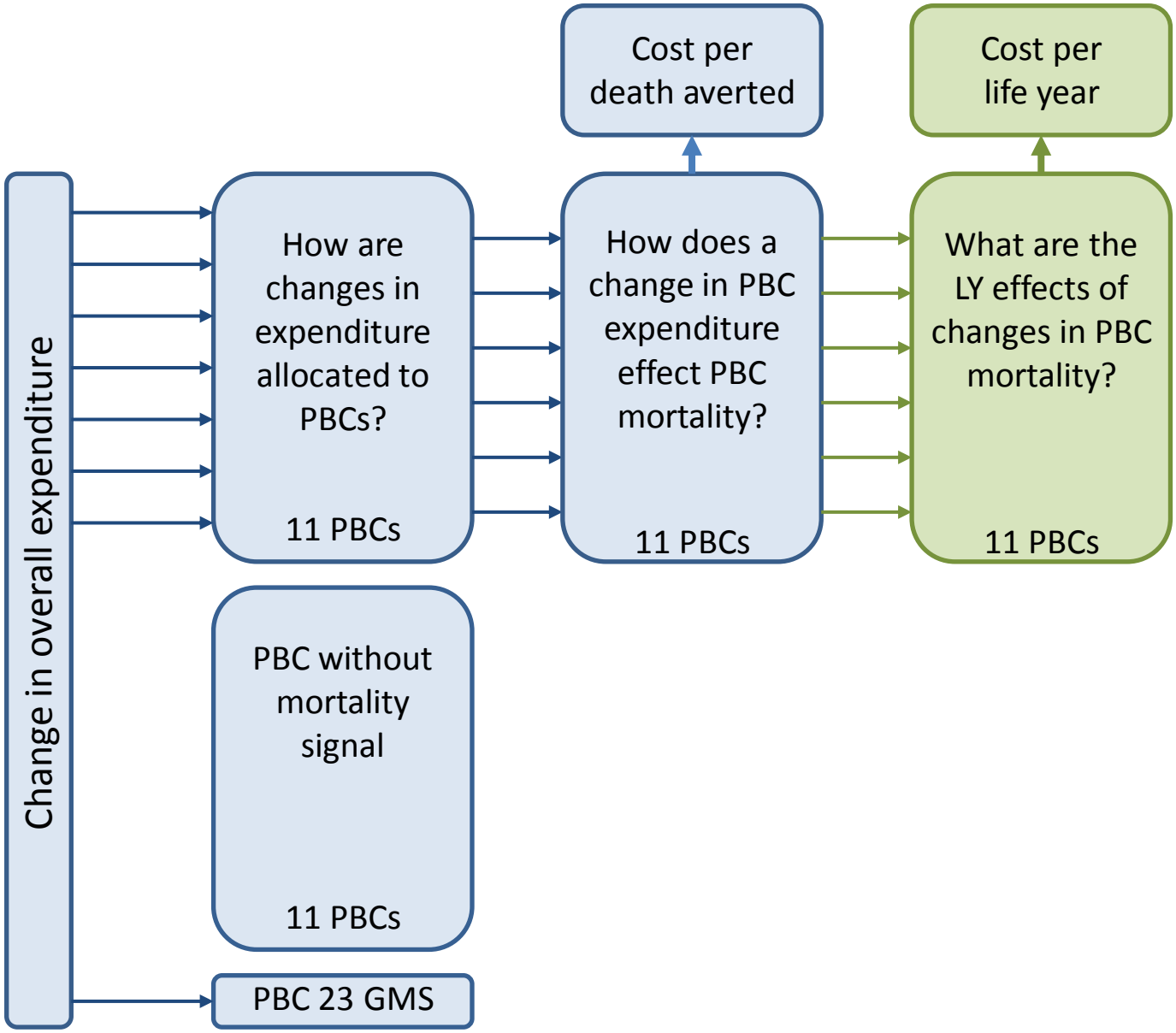
How can we estimate effects on life years



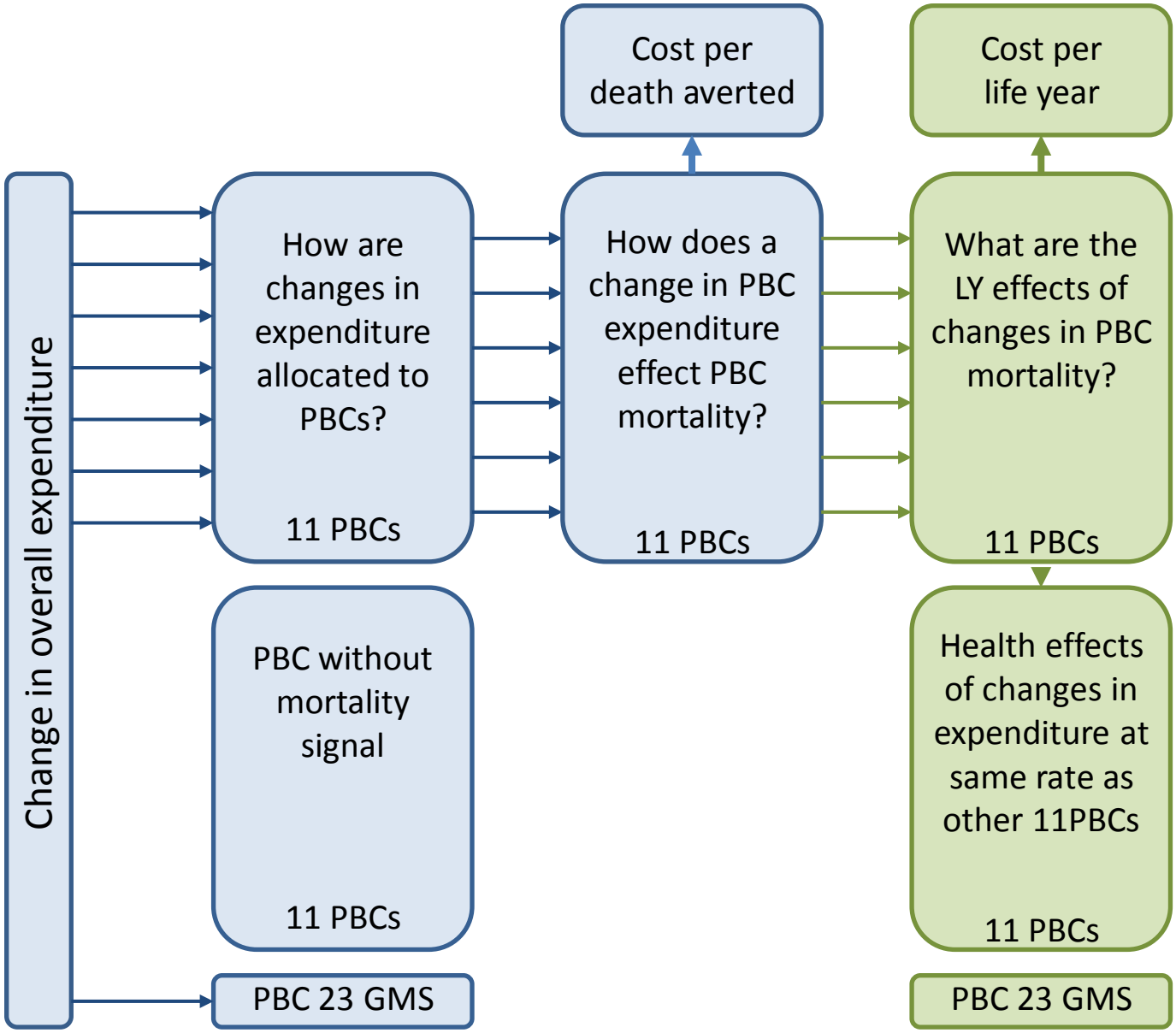
What are the life year effects of changes in PBC mortality?

- Effects on all deaths within a PBC (group of ICD codes)
  - Not all deaths are reported by PCT (all ICD codes)
  - Apply % effects (observed) to deaths in all ICD codes in PBC (ONS)
- What years of life are lost due to mortality?
  - LE of the age and gender distribution in each ICD within the PBC
  - Age of death compared to LE
  - Account for all deaths below LE *and above LE*
    - Accounts for deaths from other causes
  - Death averted faces the mortality risk of a matched population

How can we estimate effects on life years



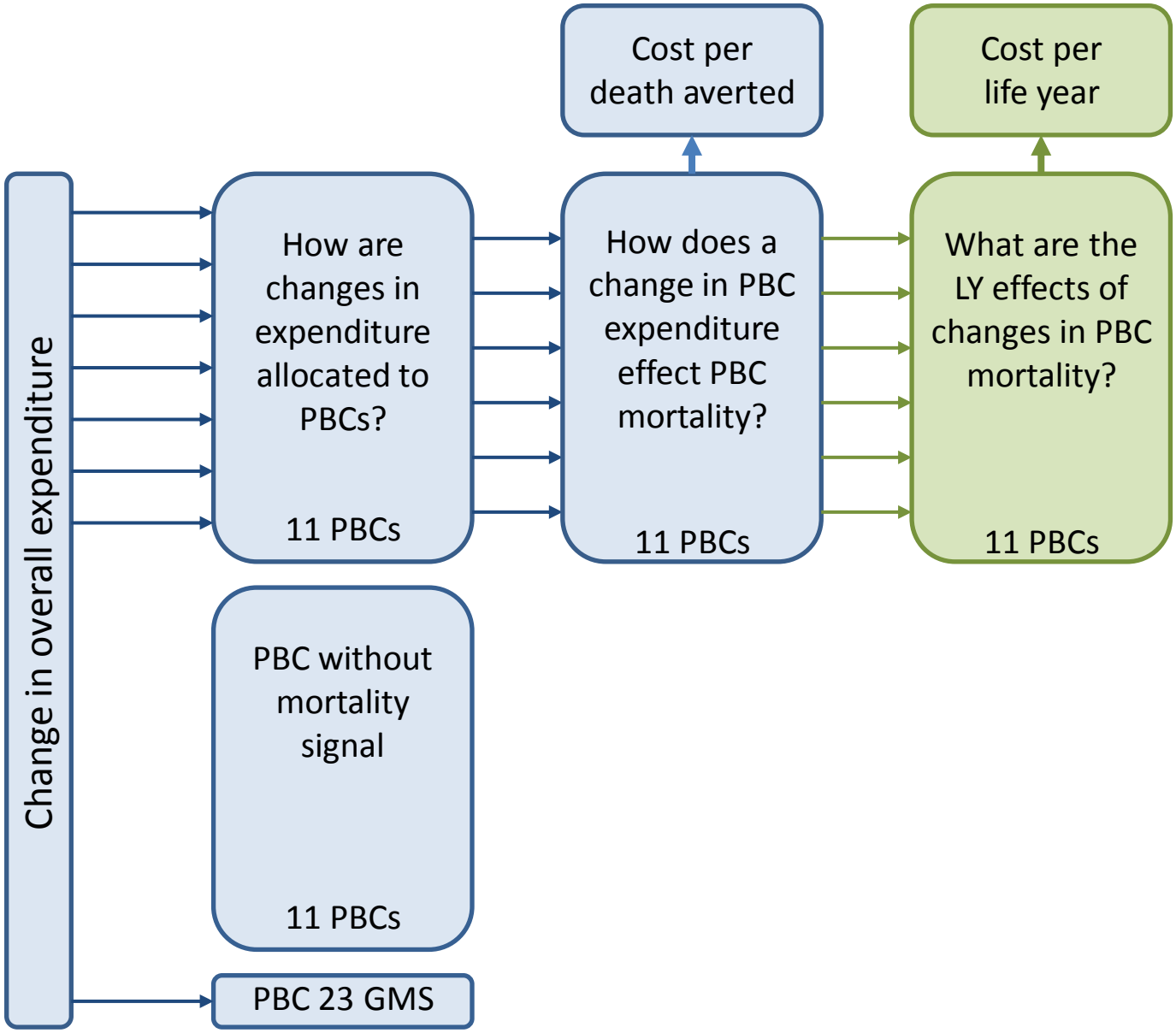
How can we estimate effects on life years



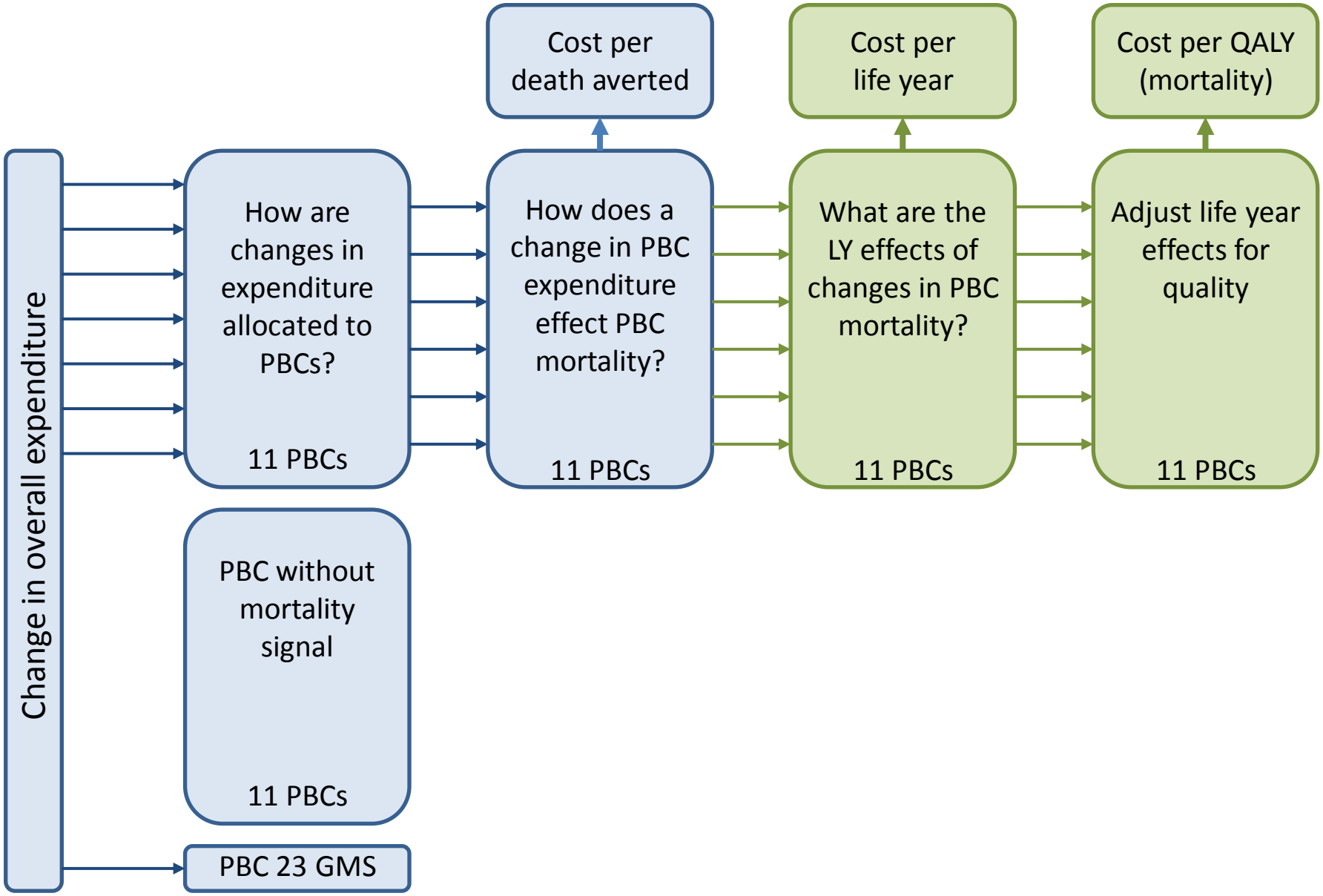
Estimates of the threshold (2008-09)

	Cost per death averted	Cost per life year
Qol associated with LYs	-	*1*
Qol during disease	-	*0*
YLL per death averted	-	*4.5 YLL*
QALYs per death averted	-	*4.5 YLL*
11 PBCs (with mortality)	£105,872	£23,360
All 23 PBCs	£114,272	**£25,214**

How can we adjust life years for quality?



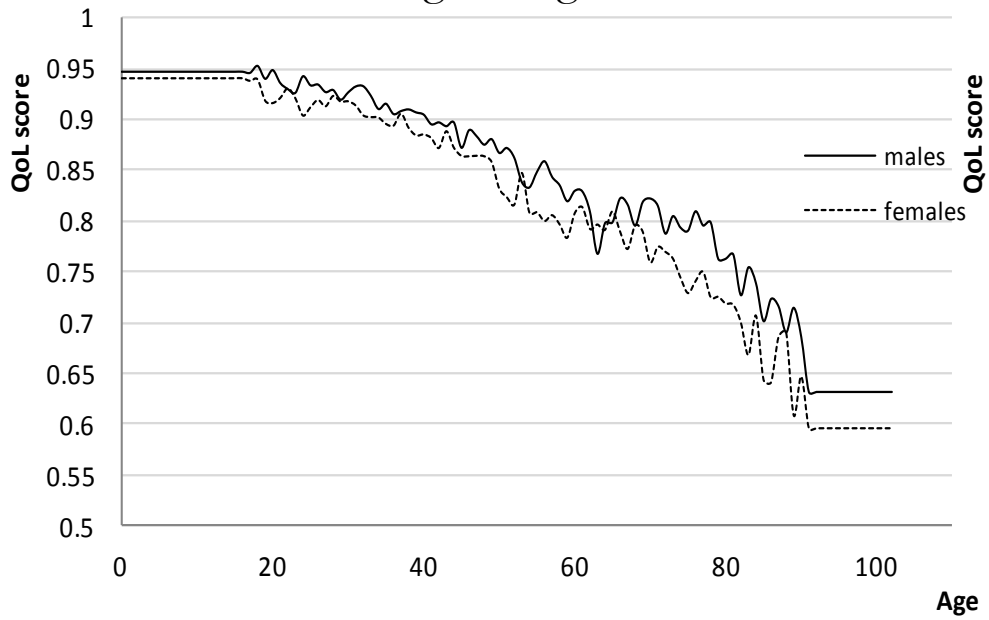
How can we adjust life years for quality?



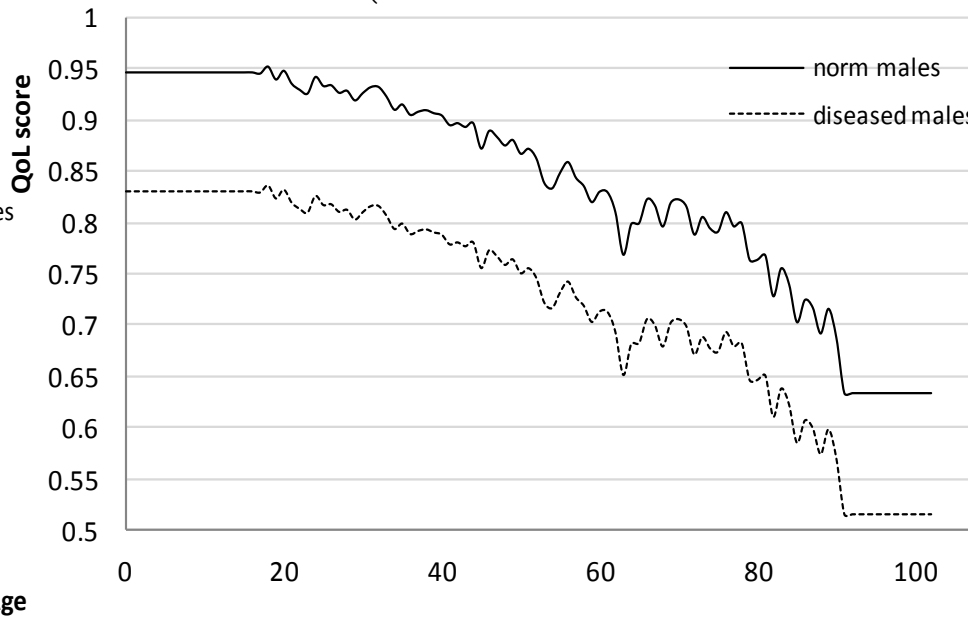
Adjusting life year effects for quality

- Life years lived at QoI norms by age and gender
  - All disease is acute *or* symptoms are 'curable'
- Life years lived with QoI of disease (decrement to norms)
  - All disease is chronic (life long) *and* 'incurable'
- Assumptions are relaxed using measures of burden

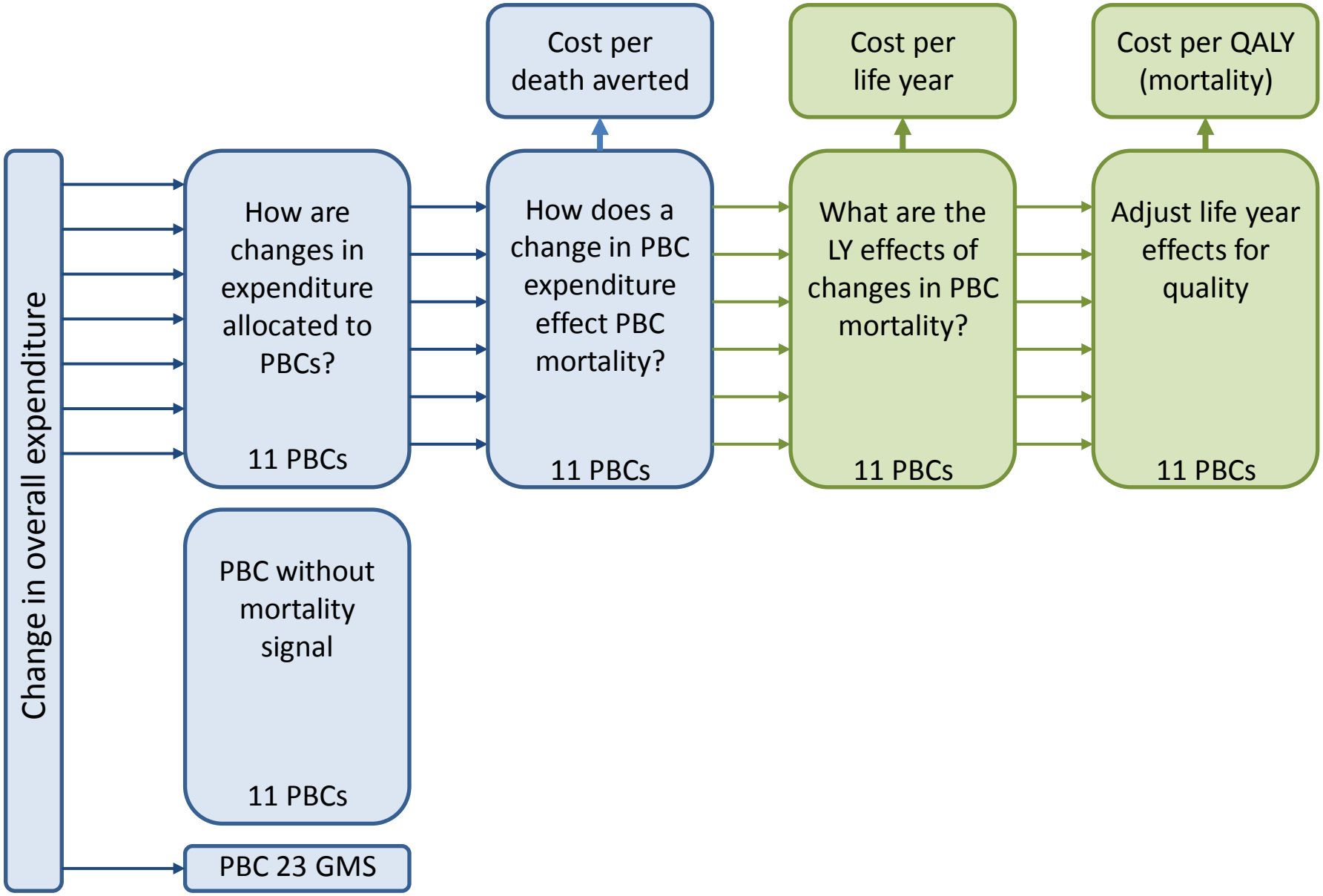
Quality of life for the general population by age and gender



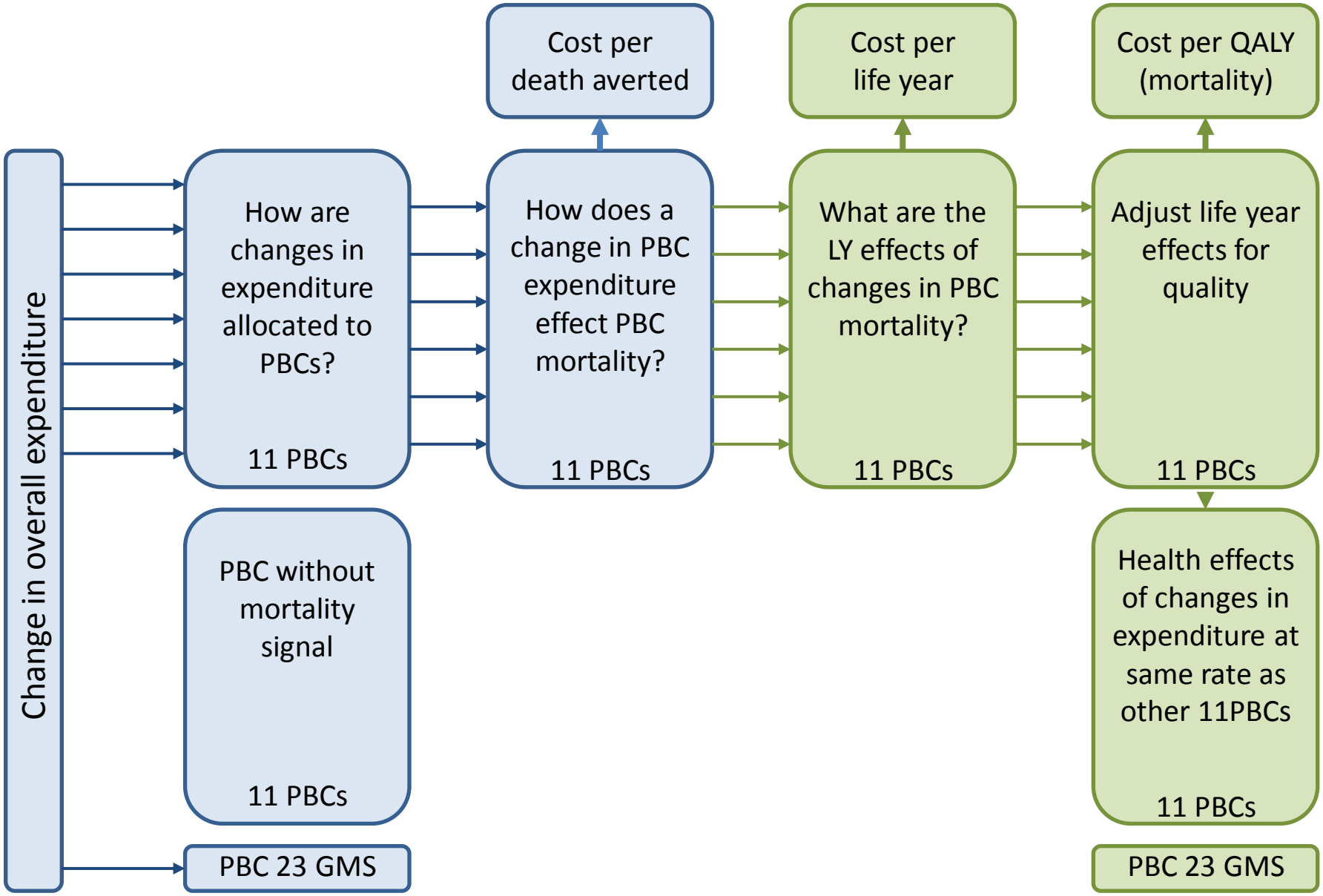
Quality of life for males in PBC1 (infectious disease



How can we adjust life years for quality?



How can we adjust life years for quality?



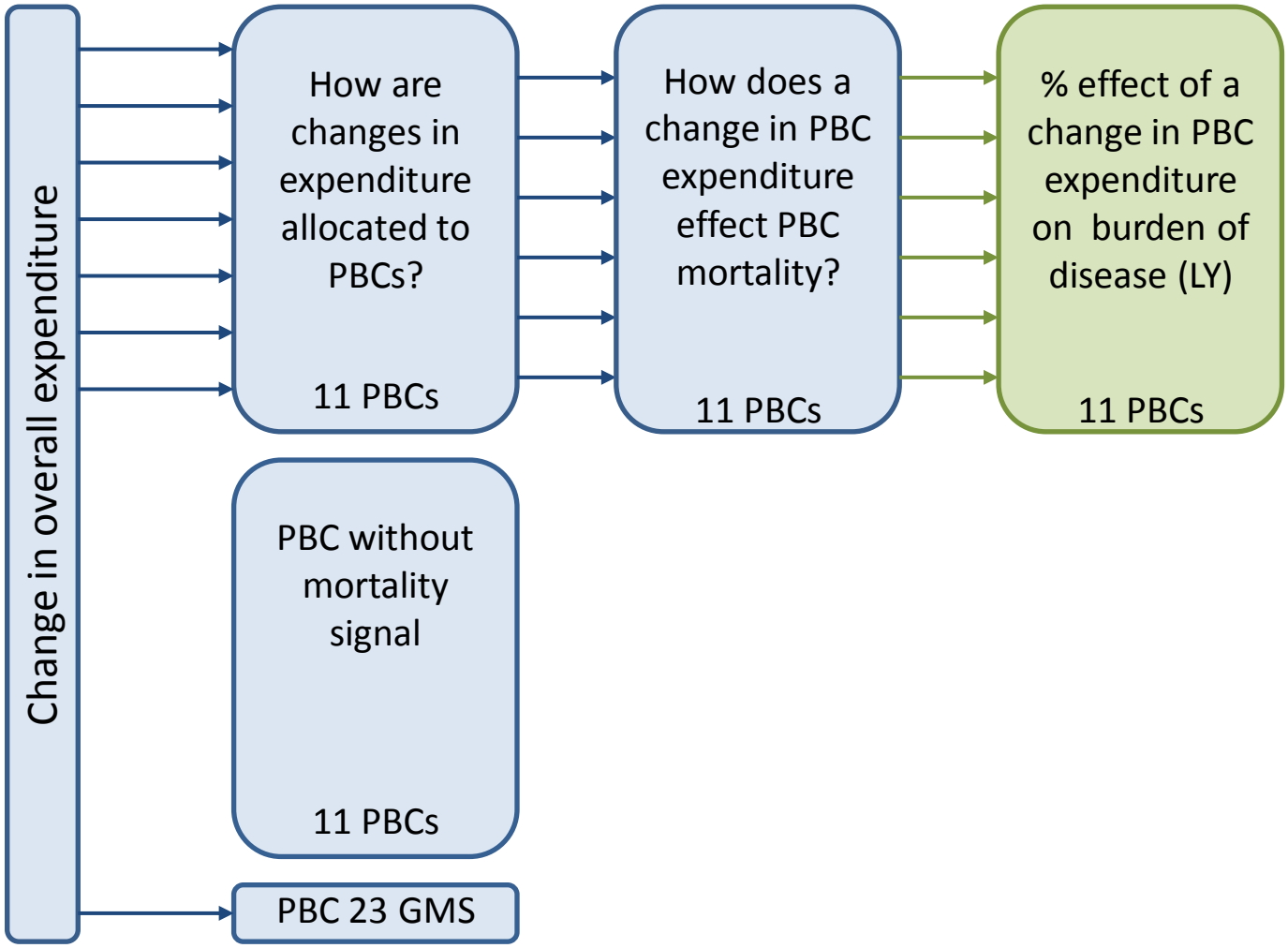
Estimates of the threshold (2008-09)

	Cost per death averted	Cost per life year	Cost per QALY (mortality effects only)	
Qol associated with LYs	-	*1*	*Norms*	*Disease*
Qol during disease	-	*0*	*0*	*0*
YLL per death averted	-	*4.5 YLL*	*4.5 YLL*	*4.5 YLL*
QALYs per death averted	-	*4.5 YLL*	*3.8 QALY*	*3.0 QALY*
11PBCs (with mortality)	£105,872	£23,360	£28,045	£35,397
All 23 PBCs	£114,272	£25,214	**£30,270**	£38,206

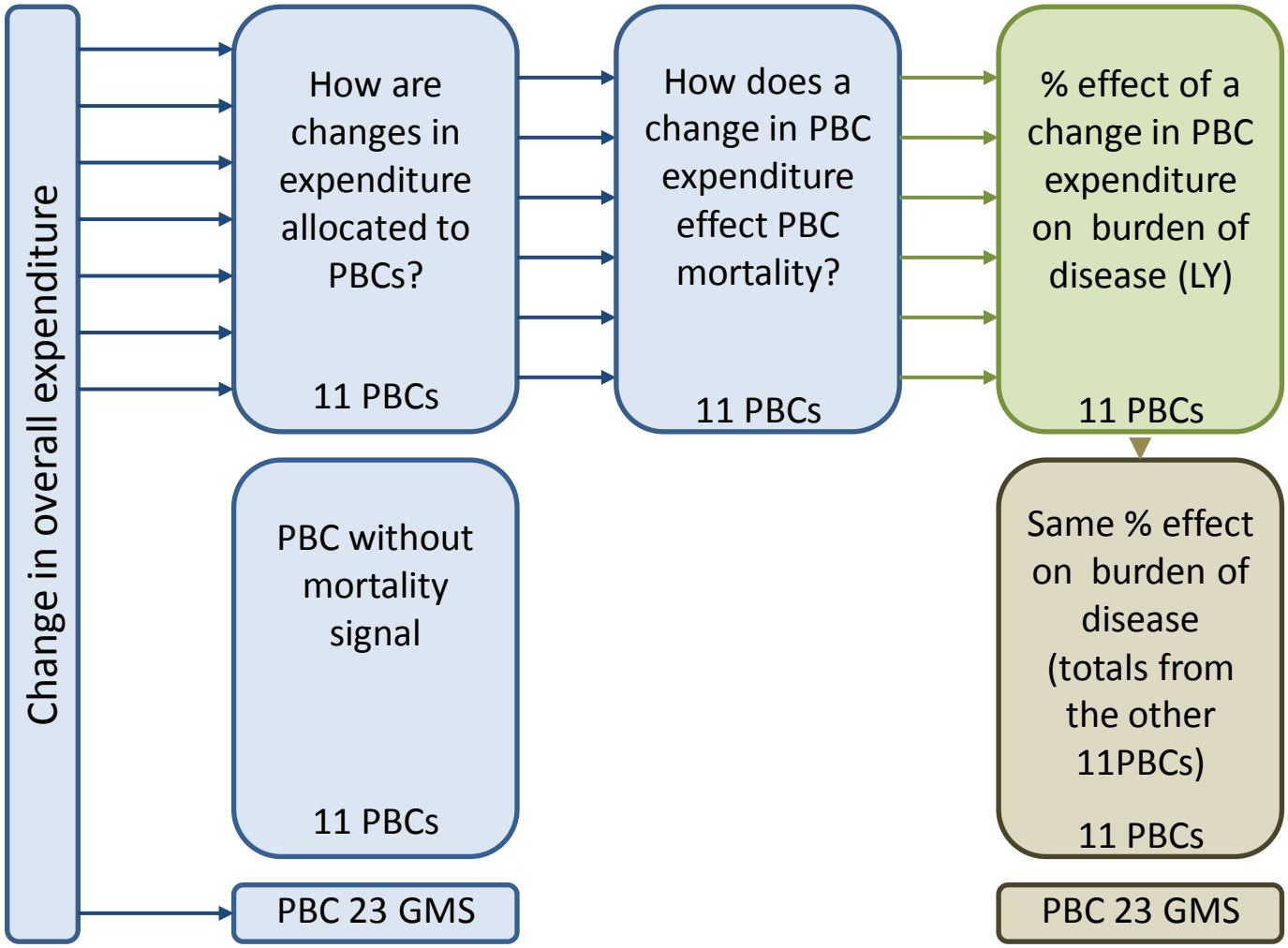
How can we account for possible effects on quality of life?

- No observations of quality life by PBC at PCT level
  - Quality of life is important in 11 PBCs with mortality
  - Mortality is (almost) irrelevant in the other 11 PBCs
  - Much NHS activity is primarily to improve quality of life
- Possible responses
  - Assume that NHS expenditure has no effects on quality of life
  - Use what can be observed to impute what cannot
    - Effects on quality of life in 11 PBCs with mortality
    - QALY effects in the other 11 PBCs
  - Use all the information we have about the other 11 PBCs

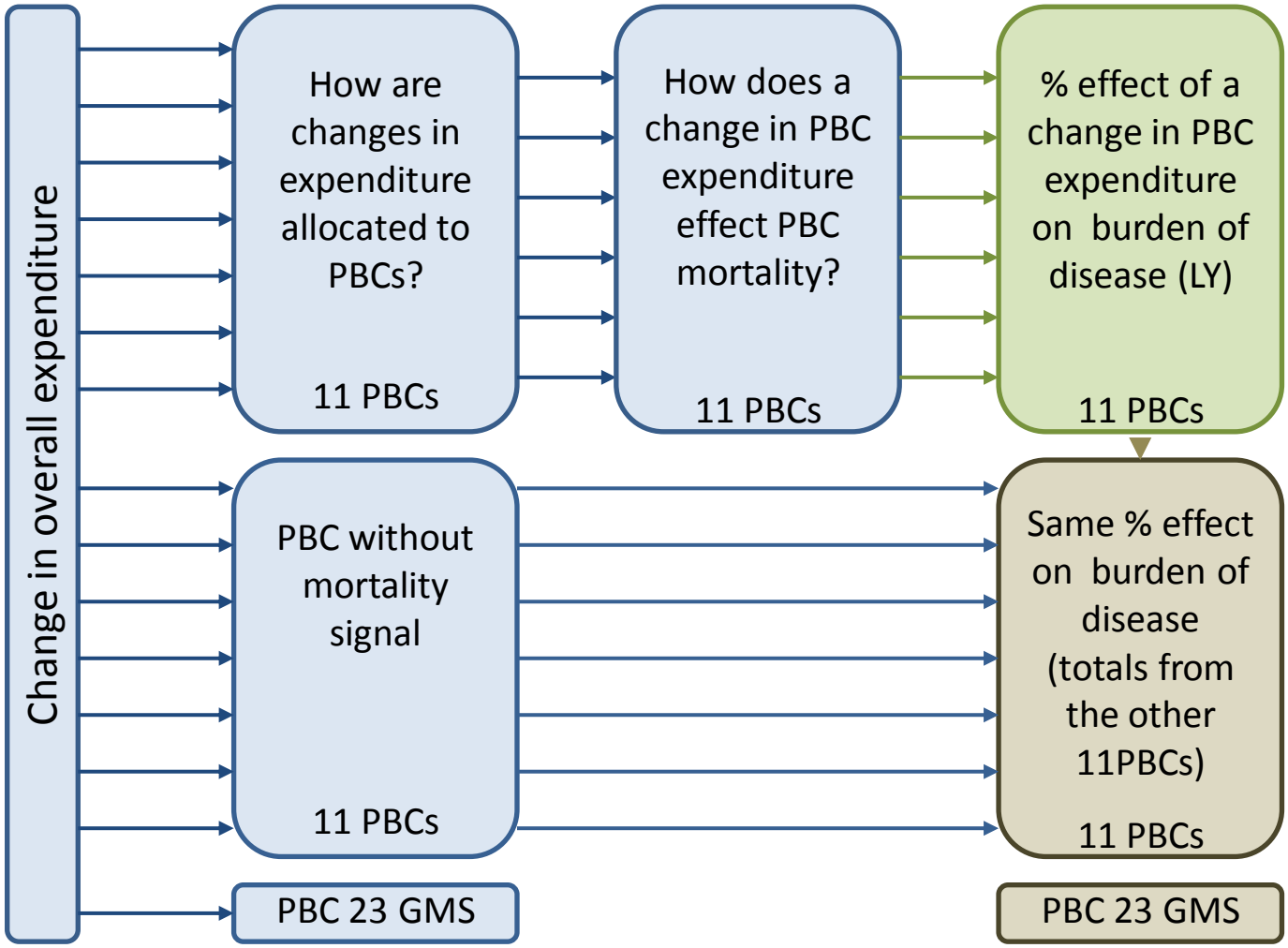
How can we account for possible effects on quality of life?



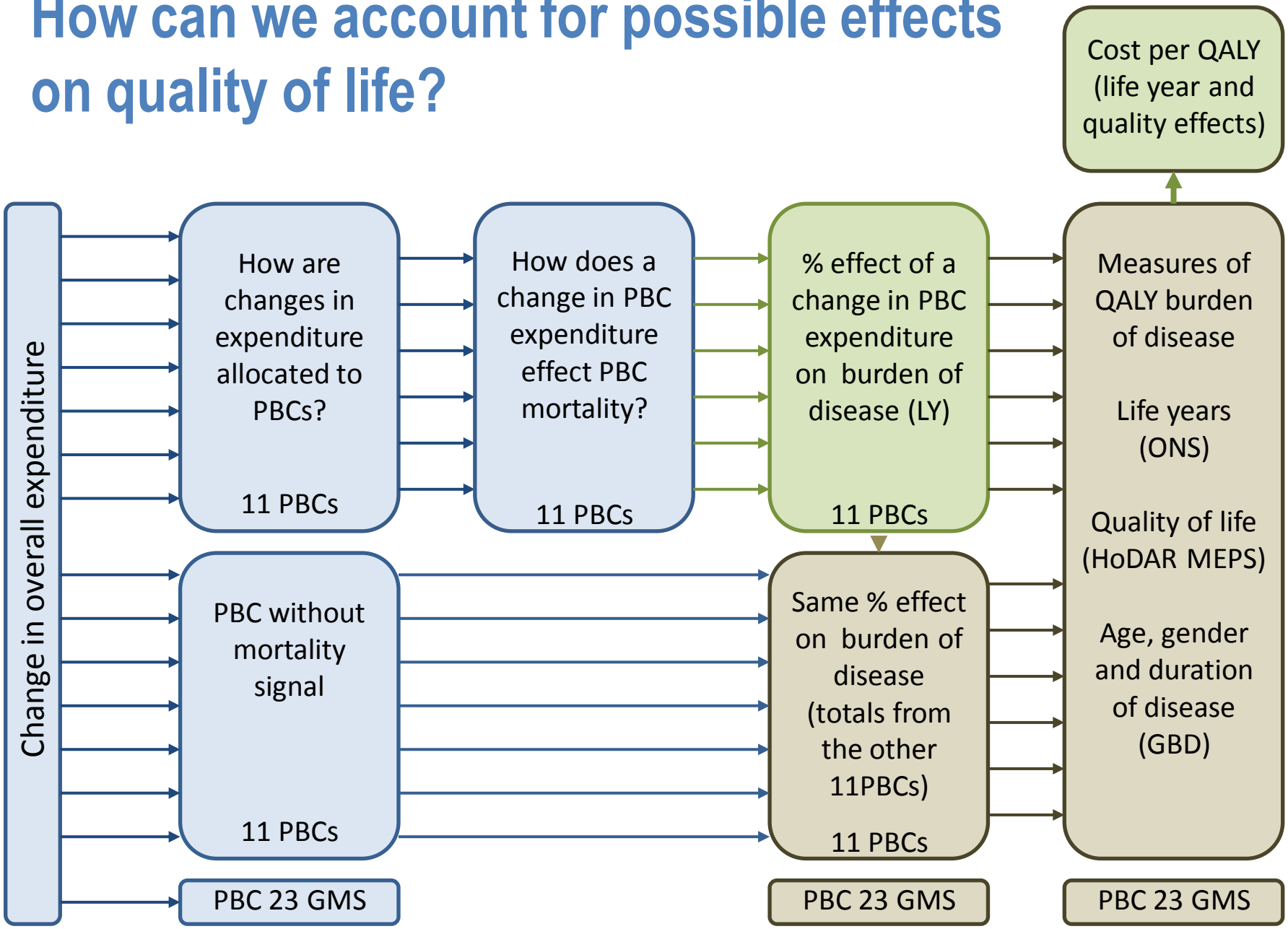
How can we account for possible effects on quality of life?



How can we account for possible effects on quality of life?



How can we account for possible effects on quality of life?



Estimates of the threshold (2008-09)

	Cost per death averted	Cost per life year	Cost per QALY (mortality effects)	Cost per QALY
QoI associated with LYs	-	*1*	*Norms*	*Based on burden*
QoI during disease	-	*0*	*0*	*Based on burden*
YLL per death averted	-	*4.5 YLL*	*4.5 YLL*	*4.6 YLL*
QALYs per death averted	-	*4.5 YLL*	*3.8 QALY*	*12.7 QALY*
11 PBCs (with mortality)	£105,872	£23,360	£28,045	£8,308
All 23 PBCs	£114,272	£25,214	£30,270	**£18,317**

What are the expected health consequences of £10m?

	Change in spend (£000)	Additional deaths	LY lost	Total QALY lost	Due to premature death	Quality of life effects
Totals	£10,000	37	167	546	107	439
Cancer	£324.000	3	27	19	18	1
Circulatory	£550.000	17	84	78	53	25
Respiratory	£332.000	10	12	166	7	159
Gastro-intestinal	£232.000	2	18	32	12	20
Infectious diseases	£237.000	1	4	11	3	9
Endocrine	£137.000	< 0.5	4	44	2	42
Neurological	£433.000	1	5	79	3	76
Genito-urinary	£336.000	2	2	8	1	6
Trauma & injuries*	£558.000	0	0	0	0	0
Maternity & neonates*	£495.000	< 0.05	< 0.5	0	< 0.5	< 0.5
Disorders of Blood	£292.000	< 0.5	1	10	1	10
Mental Health	£2,532.000	2	7	51	4	46
Learning Disability	£147.000	< 0.5	1	2	< 0.5	1
Problems of Vision	£275.000	< 0.05	< 0.5	4	< 0.5	3
Problems of Hearing	£124.000	< 0.05	< 0.5	6	< 0.05	6
Dental problems	£409.000	< 0.05	< 0.05	7	< 0.05	7
Skin	£279.000	< 0.5	1	2	1	1
Musculo skeletal	£514.000	< 0.5	2	25	1	24
Poisoning and AE	£132.000	< 0.05	< 0.5	1	< 0.5	1
Healthy Individuals	£501.000	< 0.05	< 0.5	0	< 0.05	< 0.5
Social Care Needs	£426.000	0	0	0	0	0
Other (GMS)	£735.000	0	0	0	0	0

Is it likely to be an under or over estimate?

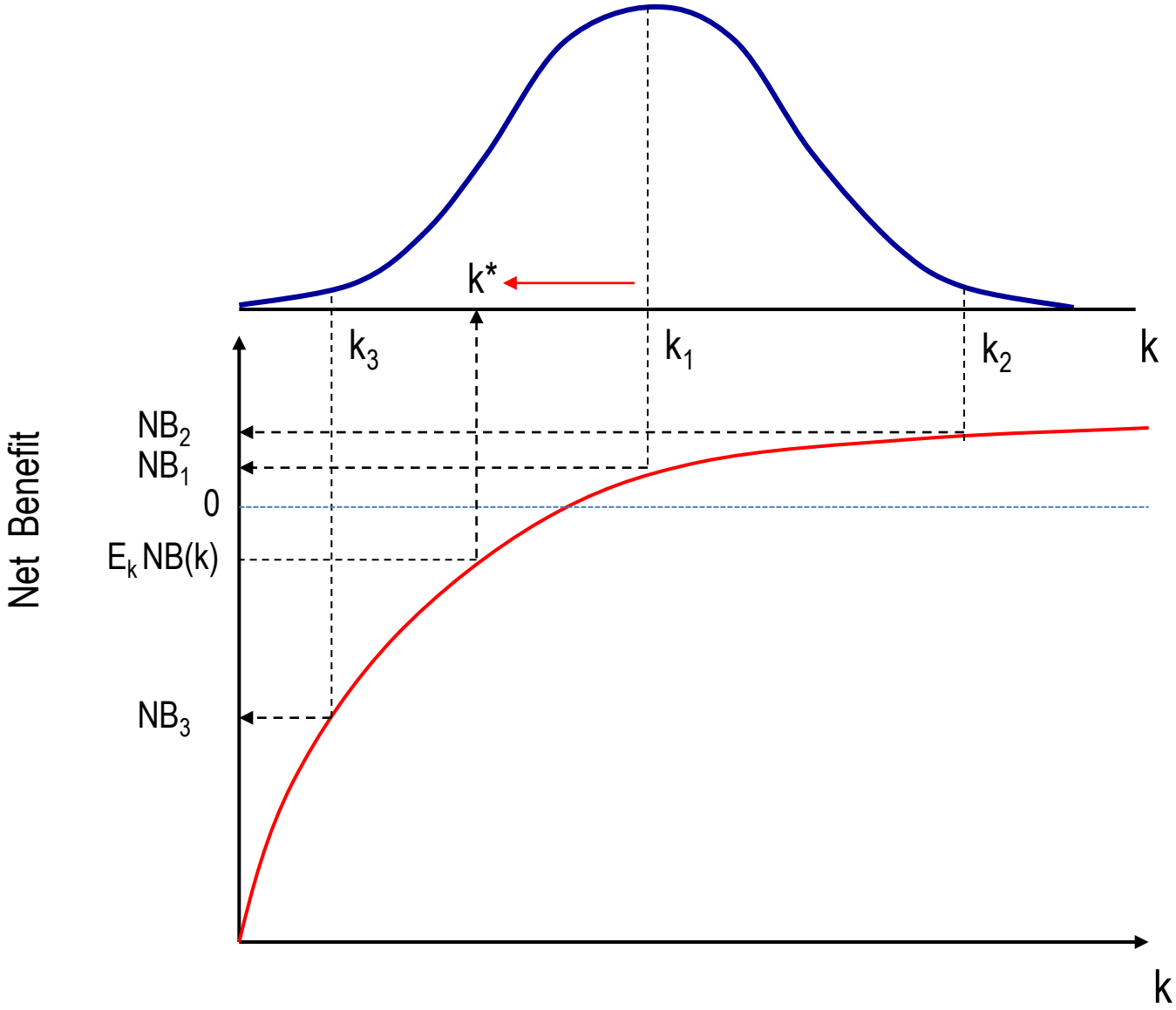
- Health effects over estimated (threshold underestimated)?
  - Deaths averted returns the individuals to the mortality risk of the general population (matched for age and gender)
  - Small positive correlation between expenditure and outcome elasticities
  - Apply estimates (data reported at PCT) to all PBC mortality
- Health effects under estimated (threshold overestimated)?
  - Mortality and quality of life effects restricted to one year
  - No effects of prevention (reduce incidence into the at risk population)
  - Effects of changes in GMS (and PBC22 & 16) expenditure not fully captured
  - Share of changes in expenditure favours PBCs with high cost per QALY
- Other assumptions
  - Surrogacy
    - Are % mortality effects a good surrogate for % QoI effects?
  - Extrapolation
    - Is the proportionate effect on QALY burden of changes in spend similar in the other PBCs?

Implied PBC cost per QALY

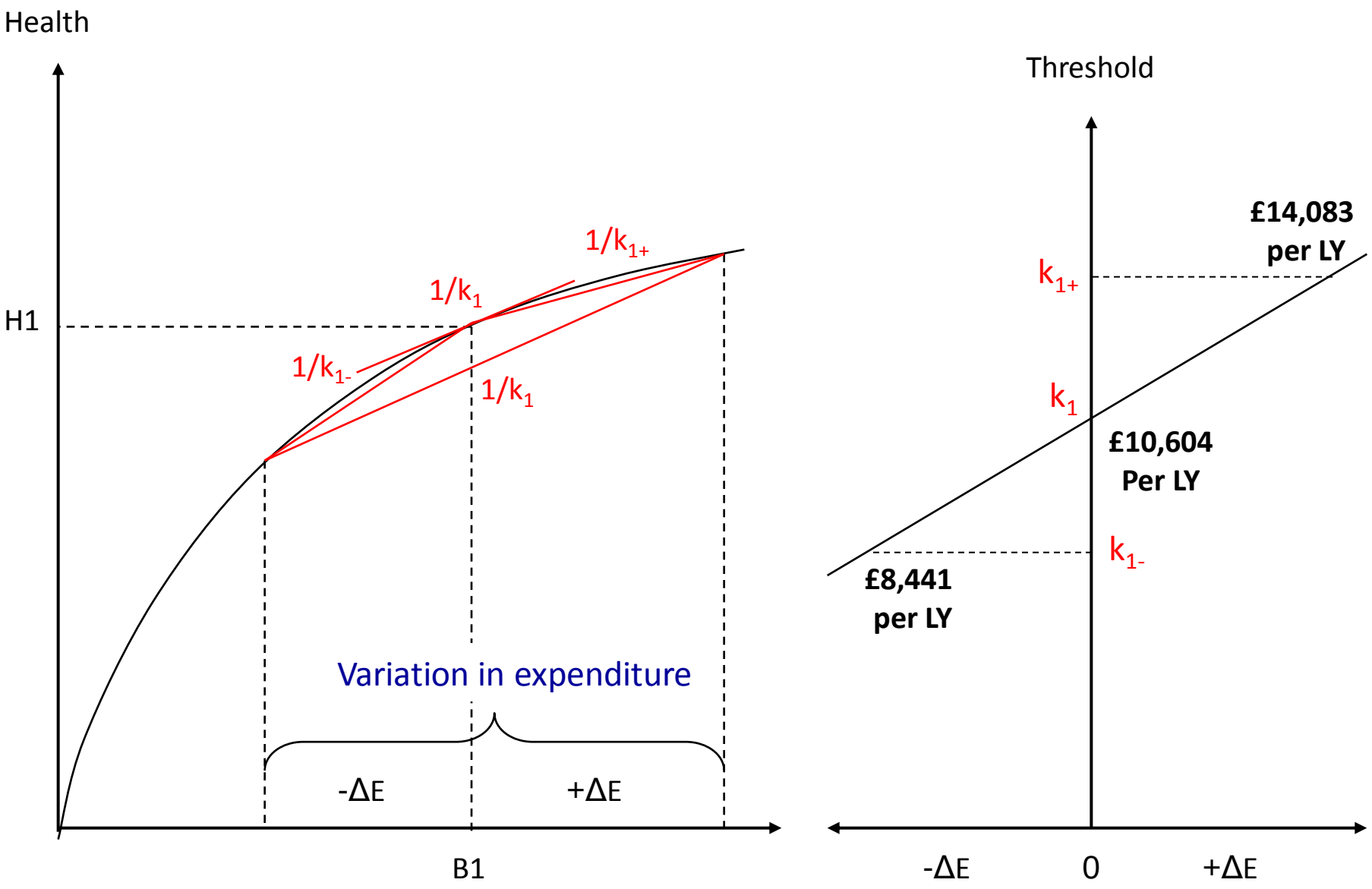
- Which PBCs matter most?
  - Share of change in spend, share of health effects and how much implied PBC cost per QALY differs from £18,317
  - 11 PBCs where proportionate effects are imputed
    - Mental health most important PBC (imputed cost per QALY £49,835)
    - Evidence suggests cost per QALY of mental health interventions lower
- Differences in the implied PBC cost per QALY
  - Misallocation of resources?
  - Social value of health effects (maternity and neonates)
  - Cannot observe quality of life effects at PCT level
    - Quality of life effects not proportional to mortality effects
    - Health effects more than proportional to QALY burden
  - Effect on outcomes in other PBCs

Implications of uncertainty in the estimate

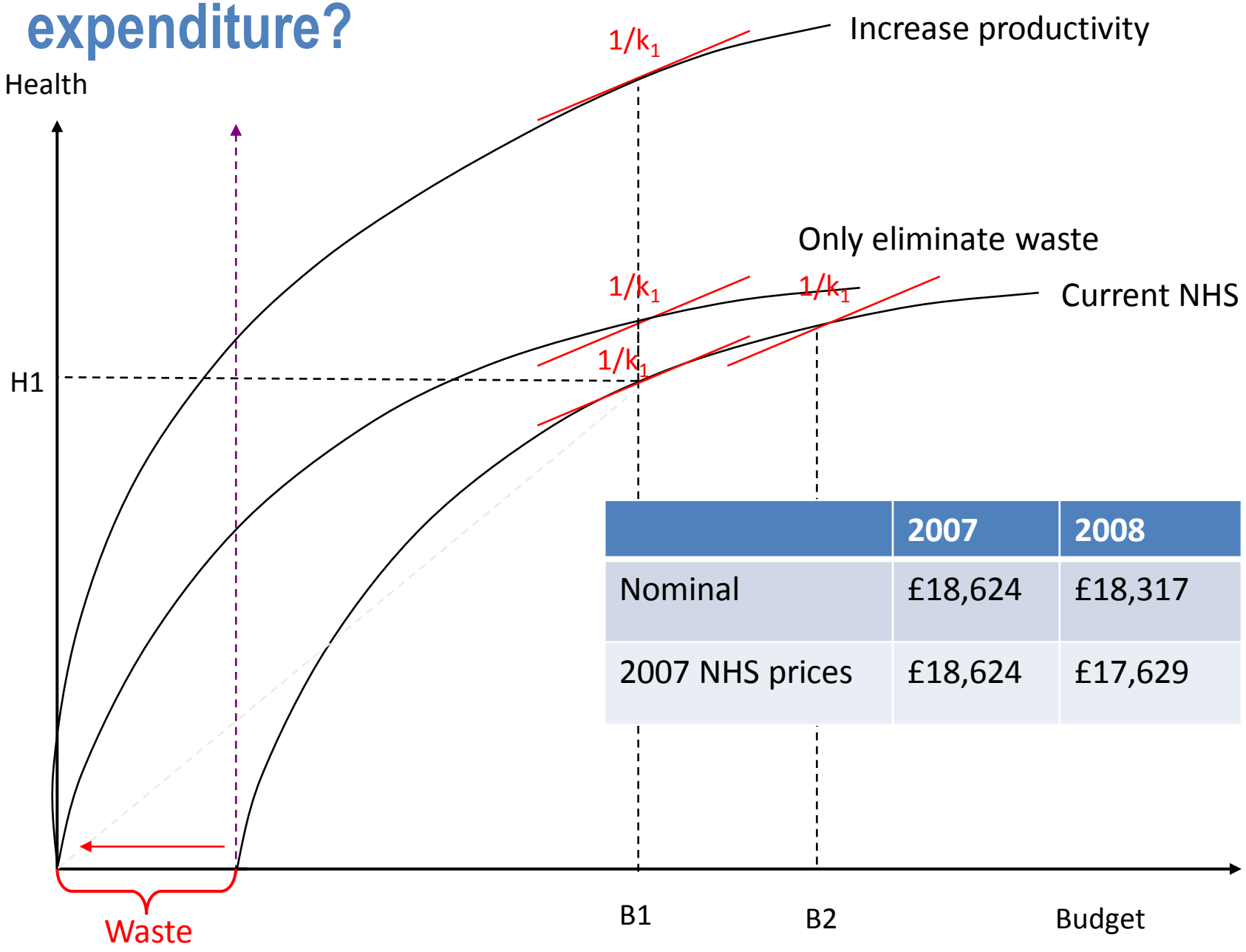
(Single threshold value that can be compared to an ICER)



Impact of investment and disinvestment?



How does the threshold change with overall expenditure?



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

Summary of considerations

- On balance £18,317 is more likely to be an over than underestimate of the threshold
  - Upper bound of the NICE threshold is almost certainly too high
  - Lower bound may also be too high
- Uncertainty in the estimate suggests a policy threshold set as less than the mean estimate
- Threshold less than the mean estimate when imposing costs on the NHS (reducing expenditure)
- No evidence of growth in threshold with increases in real budget and prices
- Some evidence that threshold more likely to fall rather than rise as NHS comes under more financial pressure

What type of data and research could improve the estimate?

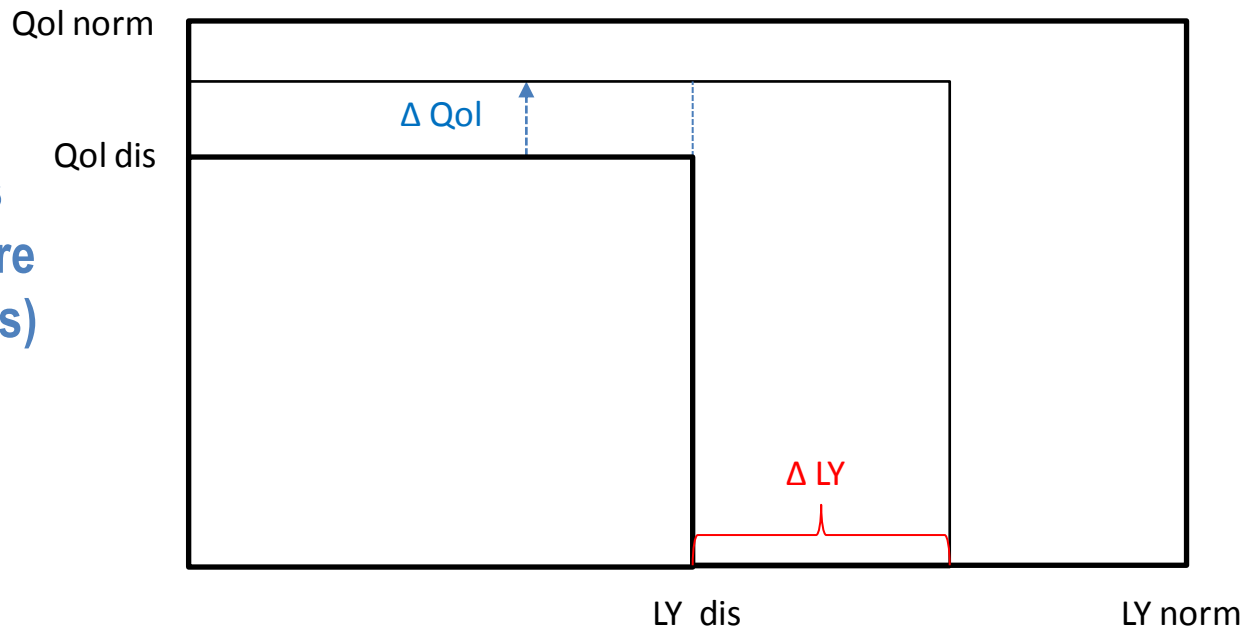
- Longer and more complex lag structure
  - Duration of effect on mortality might be feasible (capture more health effects)
  - Estimating life year effect of mortality more problematic
- Simultaneous estimation across PBCs
  - Likely to capture more health effects
- Evolving PBC data (PCT and CCG boundaries)
- Extending measures of health outcome
  - Analysis of PROMs data
  - IAPT and mental health outcomes
- Incidence and duration of disease
  - WHO GBD
  - GPRD

Additional slides

- Reserve slides if needed during discussion

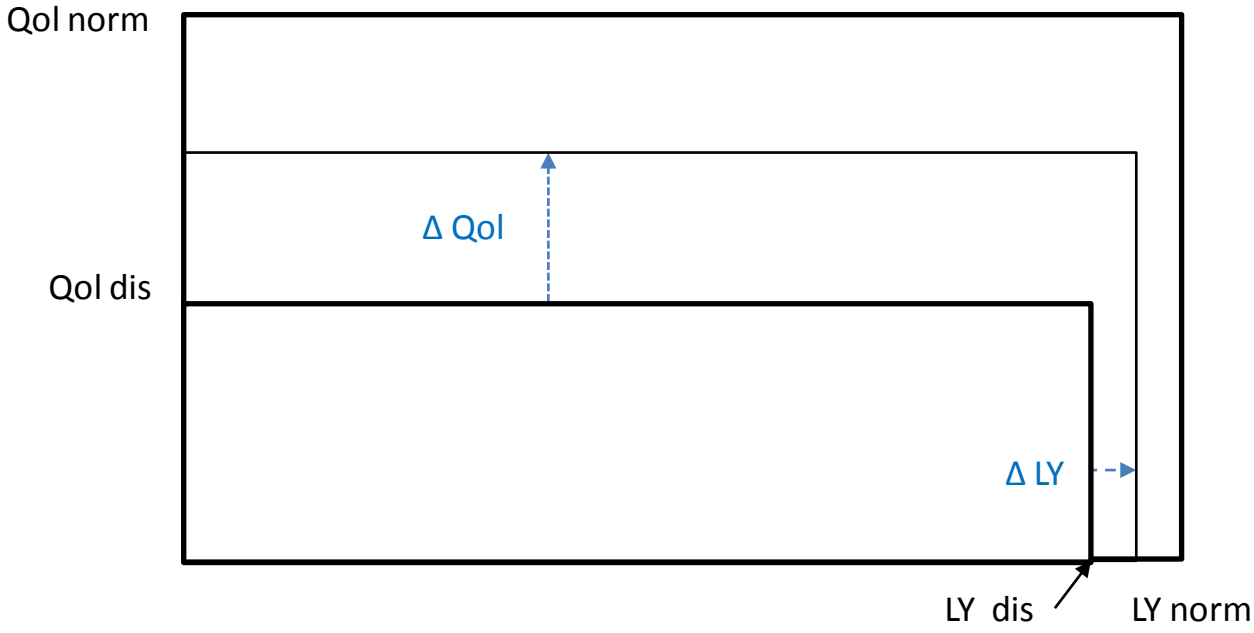
Surrogacy

Quality of life effects (each of 11PBCs where can estimate LY effects) % reduction in LY burden



Extrapolation

QALY effects (other 11PBCs) Same % effect on burden



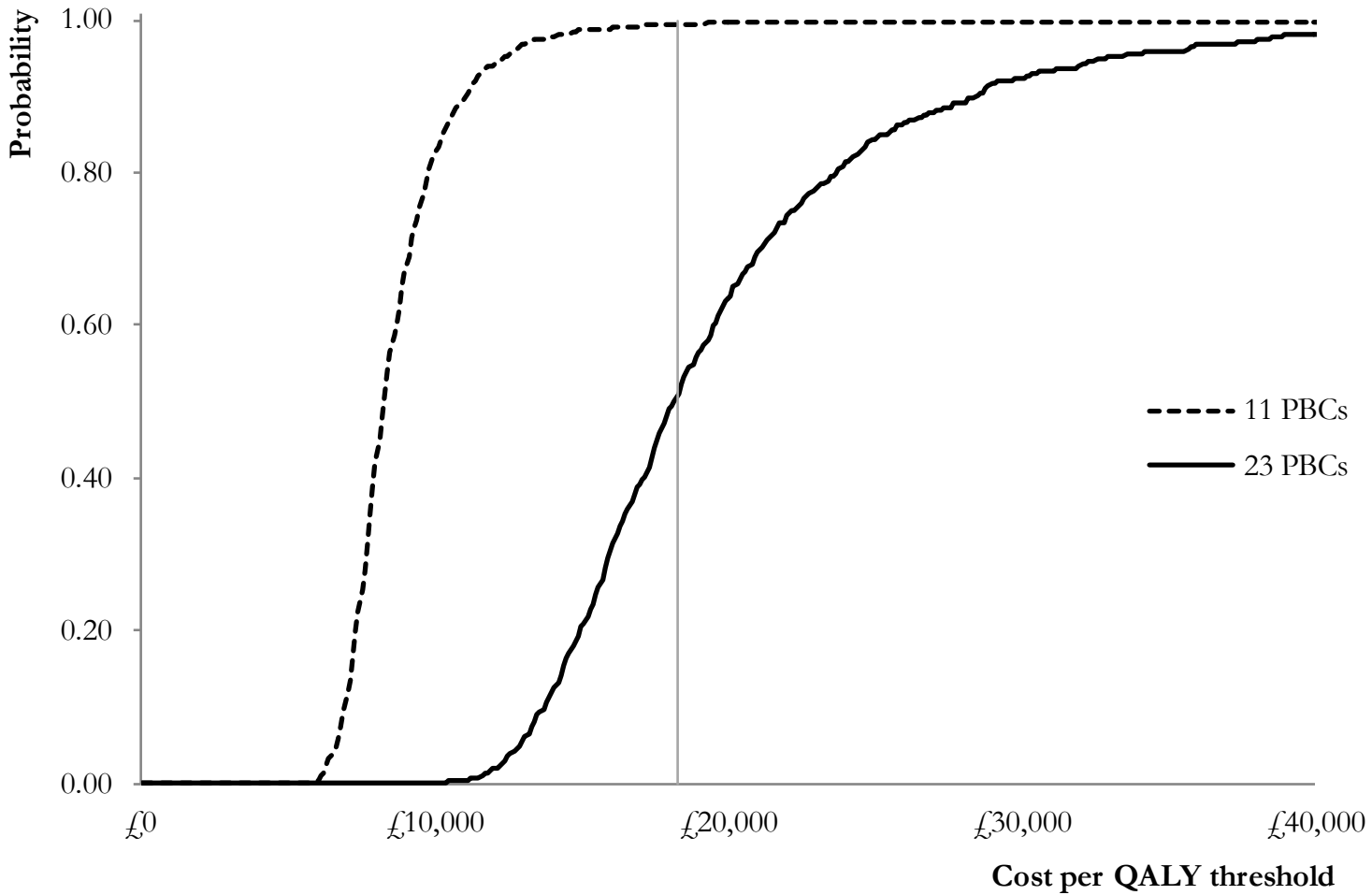
Which PBCs matter most?

	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?

An assessment of parameter uncertainty

Figure 5.1 Cumulative probability density function for the cost per QALY threshold



Decomposing QALYs

Table C.79: Decomposing estimated QALY effects by PBC (2008)

PBC		QALY change (total) [1]	QALY change (death) [2]	% QALY gained for premature death [3]	% QALY gained for disability while alive [4]
2	Cancer	1,453	1,393	96%	4%
10	Circulatory	5,125	4,054	79%	21%
11	Respiratory	10,947	758	7%	93%
13	Gastro-intestinal	2,087	1,024	49%	51%
1	Infectious diseases	14	9	67%	33%
4	Endocrine	2,921	269	9%	91%
7	Neurological	441	43	10%	90%
17	Genito-urinary	13	5	40%	60%
16	Trauma & injuries*	0	0	NA	NA
18+19	Maternity & neonates*	22	7	30%	70%
3	Disorders of Blood	689	35	5%	95%
5	Mental Health	3,397	296	9%	91%
6	Learning Disability	125	25	20%	80%
8	Problems of Vision	240	9	4%	96%
9	Problems of Hearing	434	3	1%	99%
12	Dental problems	489	0	0%	100%
14	Skin	107	39	37%	63%
15	Musculo skeletal	1,697	84	5%	95%
20	Poisoning and AE	54	9	16%	84%
21	Healthy Individuals	23	4	16%	84%
22	Social Care Needs	0	0	NA	NA
23	Other	0	0	NA	NA