# Estimating health opportunity costs
# (Re-estimating the cost per QALY threshold)

21st April 2017

## 1. Introduction

Although the national health care budget is set centrally, responsibility for the local administration of the NHS is devolved to local health authorities. Until recently, these local bodies were known as Primary Care Trusts (PCTs). PCTs were allocated fixed annual budgets by the national ministry, within which they were expected to meet expenditure on most aspects of publicly-funded health care.

With different PCTs receiving different budgets and prioritising different disease areas, this geographical variation can be exploited statistically to estimate the relationship between the level of expenditure and the health outcome achieved in each disease area. Drawing on this relationship, recent research reported a central estimate of the cost-effectiveness threshold as £12,936 per quality-adjusted life-year (QALY) for the UK (Claxton et al, 2015). This figure was based on outcome and expenditure models estimated using 2008/09 programme budgeting data and mortality data pooled for 2008, 2009 and 2010.

The estimated threshold of £12,936 is very close to that obtained from a similar analysis of both 2006/07 and 2007/08 programme budgeting data. More recent mortality and expenditure data are now available and this document outlines how we plan to update and re-estimate the earlier estimates.

## 2. Switching to local authorities (LAs) as the unit of analysis

PCTs were replaced by CCGs in April 2013 and the final issue of mortality data by PCT is available for 2008, 2009 and 2010 pooled. More recent mortality data is only available by local authority. Therefore, to update the earlier estimates we will switch from PCTs to LAs as the unit of analysis. The programme budgeting expenditure data is available by PCT until 2012/13 (and then by CCG from 2013/14). We will convert this PCT-level data to LA-level. Michael Chaplin at the DH has constructed a mapper which uses population size in 2010 to map the 151 PCTs to 152 LAs. Other data, such as the census-based variables, can be either mapped or re-generated from census small area statistics to LA-level. We will:

(i) re-generate all of our existing outcome and expenditure models for 2008/09 at PCT-level;
(ii) re-estimate all of our existing outcome and expenditure models for 2008/09 with all variables mapped to LA-level ; and
(iii) re-estimate (ii) using actual LA-level data where possible (e.g., for mortality and for census based variables).

A comparison of (iii) and (i) will tell us the impact of the mapper and at that point if we cannot replicate (i) then we will explore the exclusion of those PCTs that do not map well.

The census based variables date from the 2001 census. As the expenditure data relates to 2008/09 it could be argued that we should be using updated census data (i.e., for 2011). We will re-construct the census-based variables using the 2011 census and then:

(iv) re-estimate (iii) using 2011 census based variables; and
(v) re-estimate (iii) using census based variables interpolated (between 2001 and 2011) to 2008.

**3. Moving estimates forward to 2012/13**

Our latest cost-effectiveness threshold relates to 2008/09. We will update this to 2012/13 by re-estimating all of our outcome and expenditure models using:

(i) expenditure data for 2009/10 and mortality for 2009, 2010 and 2011 pooled;
(ii) expenditure data for 2010/11 and mortality for 2010, 2011 and 2012 pooled;
(iii) expenditure data for 2011/12 and mortality for 2011, 2012 and 2013 pooled; and
(iv) expenditure data for 2012/13 and mortality for 2012, 2013 and 2014 pooled.

Starting with the data for 2009, 2010 and 2011, the ONS used a different (an older) standard population for the calculation of the directly standardised years of life lost rate. This has the effect of increasing the reported mortality rate. We will investigate what impact this development has on our estimates.

**4. Moving LA-level estimates back to 2006/07**

We already have estimates of the cost-effectiveness threshold for 2006/7 and 2007/8. However, these estimates were informed by outcome and expenditure models estimated at PCT-level. For comparative purposes it might be useful to re-estimate our existing PCT-level models for 2006/07 and 2007/08 on a LA-level basis. We will therefore re-estimate all of our outcome and expenditure models at a LA-level using:

(i) expenditure data for 2007/08 and mortality for 2007, 2008 and 2009 pooled;
(ii) expenditure data for 2006/07 and mortality for 2006, 2007 and 2008 pooled.

There were 303 PCTs before 2006/07. A series of mergers reduced this number to 152 in October 2006. However, we could take our estimates back beyond 2006/7 because programme budgeting data for pre-2006/07 has recently been released for the 152 PCTs that came into being in October 2006. So we could estimate outcome and expenditure models using:

(iii) expenditure data for 2005/06 and mortality for 2005, 2006 and 2007 pooled;
(iv) expenditure data for 2004/05 and mortality for 2004, 2005 and 2006 pooled;

(iv) expenditure data for 2003/04 and mortality for 2003, 2004 and 2005 pooled.

We would have to undertake some tweaking of the mortality data for these last three sets of models because there was a re-organisation of LA boundaries in April 2009 and hence the data for iii, iv and v will be on this pre-2009 basis.

**5. Generating confidence intervals for each annual threshold**

When complete, the estimates in 2 - 4 above will provide a series of 10 cross-sections from 2003/04 to 2012/13 and these will facilitate the calculation of an annual cost-effectiveness threshold for each of these ten years. We will also report the 5$^{th}$ and 95$^{th}$ intervals for each threshold estimate (based on propagating the parameter uncertainty in spend and outcome elasticities as we did in the HTA report for 2008/09). This will enable us to see how the mean estimate and confidence intervals change over time, and to get a feel for how uncertain any differences and potential trends might be.

**6. The impact of lagged spend**

The availability of a ten-year dataset offers the opportunity to explore the impact of lags and leads on the relationship between spend and mortality. For example, it is plausible that historical and current spend will affect current mortality, and that current spend will also affect future mortality. We will investigate the impact of various lag lengths on mortality using our outcome and expenditure models.

**7. The impact of GMS and public health spend**

It is difficult to estimate an outcome model for GMS and public health expenditure not least because it is difficult to identify a mortality benefit directly attributable to this expenditure (in contrast it seems entirely sensible to relate expenditure on cancer patients to cancer mortality rates). One approach that we will investigate is to add GMS and public health expenditure as exogenous regressors to our outcome equations. In principle, this will permit us to identify the disease specific health benefit associated with these more generic types of expenditure.

**8. Sensitivity of results to IV validity**

In previous work we examined the impact of uncertainty about instrument validity by undertaking an extensive sensitivity analysis. We will re-visit this issue and we will incorporate any developments in econometric theory in a further sensitivity analysis. For example, recent theory suggests that where there are potential weak instrument bias this can be mitigated to some extent by including a single instrument (see: http://econ.lse.ac.uk/staff/spischke/mhe/josh/solon_justid_April14.pdf).

**9. Panel data estimation**

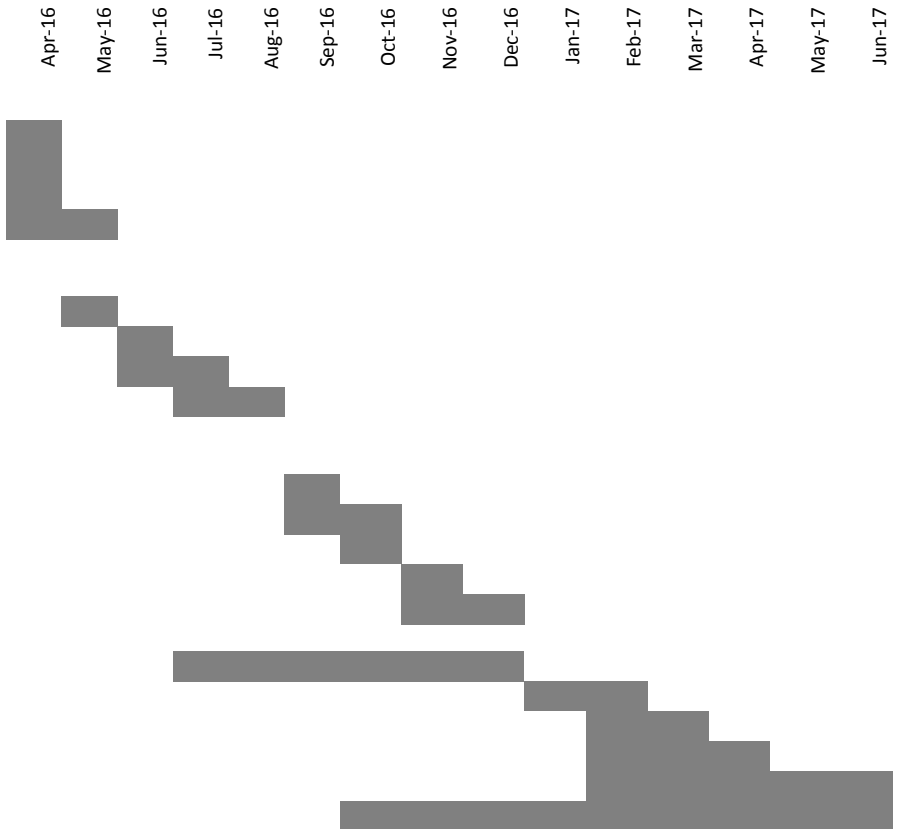
With the availability of ten years' of data panel data methods can be applied to this combined cross-section time-series data set. Such methods can generate more precise parameter estimates than a single cross-section because they can control for the influence of unobserved time invariant factors whose effect might otherwise be attributed to observed variables (e.g., where an omitted variable is correlated with both expenditure and mortality). We propose to estimate initially panel models for the big four programmes (cancer, circulatory disease, gastro-intestinal problems and respiratory disease) including pooled cross section, fixed effects (maybe with interaction), random effects and dynamic panel models. We will compare these results with those generated by single cross-section regressions.

**10. Elicitation of quantitative judgments about unknown quantities**

The parameter and structural uncertainty (see 5 and 8 above) associated with the econometrics work outlined above is only one source of uncertainty associated with an estimate of expected health opportunity costs (a central estimate of the cost per QALY threshold). A number of key assumptions are required to link the estimated mortality effects of changes in expenditure to a more complete measure of the likely health effects (QALYs). Allowing judgements to be expressed as continuous values rather than alternative combinations of categorical assumptions (scenarios) would better reflect this source of uncertainty. By eliciting quantitative judgments about all the unknown quantities while capturing the uncertainty both within and between those providing such judgments (experts), it is possible to capture this important source of uncertainty in estimating expected health opportunity costs. A formal quantitative elicitation process will be conducted, using established methods and drawing on relevant clinical and policy experts. The results of this elicitation exercise will allow the impact of the assumptions required and uncertainty associated with them to be reflected in any central estimate and in the uncertainty associated with possible values.

Draft timelines for the above pieces of work are shown below.

**Draft timelines for estimation of outcome and expenditure models for threshold update**




2 Switching to LAs as unit of analysis with 2008/9 spend data
- (i) re-generate outcome and spend models for 2008/9 at PCT-level
- (ii) re-estimate 1(i) with variables mapped to LA-level
- (iii) re-estimate 1(ii) using actual LA-level data where possible
- (iv) re-estimate 1(iii) replacing census 2001 with census 2011 data

3 Moving LA-level estimates forward to 2012/13
- (i) Estimate outcome and spend models at LA-level for 2009/10
- (ii) repeat 2(ii) using spend for 2010/11
- (iii) repeat 2(ii) using spend for 2011/12
- (iv) repeat 2(ii) using spend for 2012/13

4 Moving LA-estimates backwards to 2003/04
- (i) Re-estimate outcome and spend models for 2007/08 at LA-level
- (ii) Re-estimate outcome and spend models for 2006/07 at LA-level
- (iii) Re-estimate outcome and spend models for 2005/06 at LA-level
- (iv) Re-estimate outcome and spend models for 2004/05 at LA-level
- (v) Re-estimate outcome and spend models for 2003/04 at LA-level

5 Examining impact of uncertainty on mean and CI estimates

6 Examining the impact of lagged expenditure on current mortality

7 Examining the impact of GMS and public health in outcome models

8 Sensitivity of results to IV validity

9 Panel data estimation of outcome and expenditure models

10 Elicitation process