USING HEALTH STATE UTILITY VALUES IN MODELS EXPLORING THE COST-EFFECTIVENESS OF HEALTH TECHNOLOGIES

ONLINE APPENDIX

Methods Used To Estimate HSUVs For Comorbid Health Conditions

The techniques described below use mean HSUVs from cohorts with single health conditions to estimate mean HSUVs for cohorts with comorbid health conditions (CHC). There are three main methods used to estimate the utility value for a combined health state when data only exist for relevant single health states. These can be termed the “additive”, “multiplicative” and “minimum” approaches. Alternatives recently proposed include: the adjusted decrement estimator (ADE) which is a variation of the minimum method, and a simple linear model, based on multi-attribute utility theory and prospect theory, which incorporates terms representing the additive, multiplicative and minimum methods [1,2].

Given two health conditions, condition A and condition B, there are four possible combinations of these conditions: individuals have condition A but not condition B, individuals have condition B but not condition A, individuals have both condition A and condition B; individuals do not have either condition A or condition B. The HSUVs associated with these four alternatives are defined as: \( U_A \), \( U_B \), \( U_{A,B} \), and \( U_{nA,nB} \). In addition to these, the following terminology is used: \( U_{nA} \) and \( U_{nB} \) represent the HSUVs associated with not having the condition A (but could have condition B) or not having condition B (but could have condition A) respectively.

Additive method. The additive method assumes a constant absolute decrement relative to the baseline and the estimated HSUV for the additive CHC is calculated using:

\[
U_{A,B}^{\text{add}} = U_{nA,nB} - \left( (U_{nA} - U_A) + (U_{nB} - U_B) \right)
\]

(Eqn 1)

where the superscript “add” denotes the additive method.

If a baseline of perfect health is used, the additive method can be calculated using:

\[
U_{A,B}^{\text{add}} = U_A + U_B - 1
\]

(Eqn 2)

Multiplicative method. The multiplicative method assumes a constant proportional decrement relative to the baseline and the estimated HSUV is calculated using:
where the superscript “Mult” denotes the multiplicative method.

If a baseline of perfect health is used, the multiplicative method can be calculated using:

$$U_{A,B}^{Mult} = U_{nA,nB} \frac{U_A}{U_{nA}} \frac{U_B}{U_{nB}}$$  \hspace{1cm} (Eqn 3)

Minimum method. The minimum method assumes the decrement on HRQoL associated with a comorbidity is equal to the maximum decrement attributable to the individual single health conditions, and the estimated HSUV is calculated using:

$$U_{A,B}^{min} = \min(U_{nA,nB}, U_A, U_B)$$  \hspace{1cm} (Eqn 5)

where the superscript “min” denotes the minimum method.

If a baseline of perfect health is used, the minimum method can be calculated using:

$$U_{A,B}^{min} = \min(U_A, U_B)$$  \hspace{1cm} (Eqn 6)

Adjusted decrement estimator. The adjusted decrement estimator (ADE) has recently been proposed as an alternative method to estimate HSUVs for CHCs [1]. This estimator is a variation of the minimum method and assumes the estimated HSUV for the CHC has an upper bound equal to the minimum of the HSUVs from the two single health conditions. The proposed method is described by:

$$U_{A,B}^{ADE} = \min(U_A, U_B) - \min(U_A, U_B) \cdot (1 - U_A) \cdot (1 - U_B)$$  \hspace{1cm} (Eqn 7)

where the superscript “ADE” denotes the adjusted decrement estimator.

Combination model. Basu et al. recently proposed a simple linear model which incorporates terms representing the additive, multiplicative and minimum methods [2]. The model is formulated from a) an adaptation of work originally presented by Keeny and Raiffa which was based on decision theory and multi-attribute utility functions [3,4], and b) a prospect theory that proposes the value function is convex for losses with a marginal rate of decrement in value with increasing losses, as presented by Tversky and Kahneman (1992) [5]. The model is defined by:
\[ U_{A,B}^{\text{comb}} = 1 - \left( \beta_0 + \beta_1 \cdot \min\left(1 - U_A, (1 - U_B)\right) + \beta_2 \cdot \max\left(1 - U_A, (1 - U_B)\right) \right) + \varepsilon \]  
(Eqn 8)

where the superscript “comb” denotes the combination model, \( \varepsilon \) the residual and the beta coefficients are obtained using ordinary least square regressions. Equation 8 uses a baseline of perfect health. Using an adjusted baseline, the combination model can be defined by:

\[ U_{A,B} = \beta_0 + \beta_1 \cdot \min\left(U_{nA} - U_A, (U_{nb} - U_B)\right) + \beta_2 \cdot \max\left(U_{nA} - U_A, (U_{nb} - U_B)\right) + \beta_3 \cdot \left(\frac{U_A}{U_{nA}} \cdot \frac{U_B}{U_{nb}}\right) + \varepsilon \]  
(Eqn 9)

The combination model reduces to the three traditional methods under the following conditions:

When \( \beta_0 = 0, \beta_1 = 1, \beta_2 = 1 \) and \( \beta_3 = 0 \), then Eqn 8 collapses to Eqn 2 (additive method)

When \( \beta_0 = 0, \beta_1 = 1, \beta_2 = 1 \) and \( \beta_3 = -1 \), then Eqn 8 collapses to Eqn 4 (multiplicative method)

When \( \beta_0 = 0, \beta_1 = 1, \beta_2 = 0 \) and \( \beta_3 = 0 \), then Eqn 8 collapses to Eqn 6 (minimum method)

Obtaining an age-adjusted multiplier

The method used to obtain an age-adjusted multiplier is provided below.

a) the mean EQ-5D score for a cohort with condition A is 0.70

b) the mean aged for this cohort is 65 years

c) the mean EQ-5D score for a cohort without condition A, at the age of 65 years is 0.80

d) the age-adjusted multiplier = 0.70/0.80 = 0.875

EQ-5D variance covariance matrix

It is possible to incorporate the uncertainty surrounding the preference-weights in probabilistic sensitivity analyses using the associated variance covariance matrices (for the EQ-5D matrix see www.nicedsu.org.uk).
References

1. Hu B, Fu AF, Predicting utility for joint health states, a general framework and a new non parametric estimator. 2010 MDM in press


