**Instructions for Exercise 14: Direct Equity Weights**

**Revised Sep 2020**

**Note on spreadsheets**

1. The training exercise materials are available here: <https://www.york.ac.uk/che/research/equity/handbook/>
2. There are two spreadsheets: “Ex 14 – student” and “Ex 14 – solution”. Please open the “student file” to start with and go through the worksheets filling in the relevant cells yourself. You can look at the solution file if you get stuck.
3. When the spreadsheet is first opened a ‘Security Warning’ may be displayed below the menu bar. Select ‘Enable this content’.
4. This exercise was produced for the Handbook of Distributional Cost-Effectiveness Analysis by Mike Paulden, James O’Mahony and Jeff Round and edited by Richard Cookson and Christopher McCabe.

**Introduction**

The aim of this exercise is to show you how to apply direct equity weights to health effects and health opportunity costs, both by social group and by disease group, and how to display and interpret the results in the equity-efficiency impact plane.

The exercise is based on the illustrative example of Nicotine Replacement Therapy in England. Nicotine replacement therapy (NRT) to help people stop smoking or chewing tobacco is a classic example of a preventive healthcare intervention aimed at improving health and reducing health inequality. You are asked to imagine that the UK government is considering three national policy options for NRT in England:

1. No Public NRT: do not provide any public subsidy for nicotine replacement therapy

2. Universal NRT: offer free nicotine replacement therapy to all smokers

3. Proportional Universal NRT: Universal NRT with additional resources to encourage uptake in disadvantaged communities

We provide the group-level distributions of health benefit and health opportunity cost resulting from these three options, based on the calculations detailed in handbook exercises 8 and 9. Your task now is to use direct equity weights to evaluate which of these three options is the best, by applying suitable direct equity weights to health effects and health opportunity costs. Unlike Handbook Exercises 12 and 13 on indirect equity weighting, we do not calculate equity weights indirectly based on information about the baseline and final distributions of health-adjusted life expectancy at birth and the decision maker’s degree of health inequality aversion. Rather, we apply equity weights directly to health benefits and costs.

The first stage involves assigning an equity weight to HALYs for patients in each social group. Each equity weight is then multiplied by the estimated HALYs for the social group in question to derive an estimate of *equity-weighted* HALYs. Not applying equity weights (as in standard CEA) is equivalent to applying an equity weight of 1 to every social group, in line with the standard value judgement that “a HALY is a HALY is a HALY”. Since equity weights are multiplicative, an equity weight above 1 yields equity-weighted HALYs higher than standard HALYs, while an equity weight below 1 yields equity-weighted HALYs that are lower than standard HALYs.

The second stage involves calculating the incremental net health benefit for each social group, for each of the three combinations of NRT policy options, with and without equity weights. An estimate of the overall incremental net health benefit, across all social groups, will also be calculated and interpreted in each case. Where equity weights are assigned, the HALYs for patients in one or more social groups may be given greater or lesser consideration than the HALYs for patients in other social groups. For clarity, we will refer to estimates of incremental net health benefit calculated following the application of equity weights as *equity-weighted* incremental net health benefit. In the absence of equity weights, the HALYs for patients in each social group are given equal consideration when calculating incremental net health benefit; for clarity, we refer to this as the *unweighted* incremental net health benefit.

The third stage involves plotting and interpreting an equity-efficiency impact plane, allowing for a graphical interpretation of which policy option is the most desirable, given the assigned equity weights.

As an optional additional stage, an equity weight can be assigned to HALYs associated with the disease or risk factor targeted by the intervention (in this case smoking). Decision makers sometimes wish to give higher priority to people with certain diseases or risk factors (for example, especially severe or rare conditions) and lower priority to others (for example, especially mild or common conditions). This disease group equity weight can be assigned instead of, or in addition to, the equity weights previously assigned to HALYs for patients based on their social group. The impact of such an equity weight can also be considered on the equity impact plane.

Distributional cost-effectiveness analysis considers the *equity-weighted* incremental net health benefit for each policy option, whereas a conventional cost-effectiveness analysis is instead based upon estimates of the *unweighted* incremental net health benefit (i.e. the vertical axis of the equity impact plane only). Applying equity weights may therefore result in a different policy option appearing desirable in DCEA as compared to standard CEA.

## **Step-by-step guide**

STEP 1: Open the file ‘*Ex 13 - student.xlsm*’

STEP 2: Select the <Input data> worksheet. Cells C6:E15 and H6:J15 have already been completed. You will see that these reproduce the estimates from Handbook Exercise 9 of ‘incremental health benefit’ and ‘health opportunity costs’ for each social group for each of NRT policy options being compared: universal vs no NRT (columns C and H); proportional universal vs no NRT (columns D and I); and proportional universal vs universal (columns E and J). These estimates are calculated step-by-step in Handbook Exercises 8 and 9

STEP 3: Select the <Equity weights> worksheet. The cells that require completing in this exercise are coloured yellow.

Your first task is to assign a direct equity weight to HALYs for patients in each social group. You will use these weights to calculate *equity-weighted* incremental health benefits and health opportunity costs. For now, enter the following equity weights into C6:C15 (you will have the opportunity to change these later):

|  |  |
| --- | --- |
| **Social Subgroup** | **Equity weight** |
| S1 | 3.0 |
| S2 | 1.0 |
| S3 | 1.0 |
| S4 | 1.0 |
| S5 | 1.0 |
| N1 | 3.0 |
| N2 | 1.0 |
| N3 | 1.0 |
| N4 | 1.0 |
| N5 | 1.0 |

STEP 4: Examine the equity weights in the table above. You will see that the HALYs for patients in the worst-off social groups (N1 and S1) are valued three times as highly as the HALYs for all other patients. There are many other plausible sets of direct equity weights, some of which you will have the opportunity to consider later in the exercise. For the time being, we can focus on these social factor equity weights and set aside the separate “behavioural factor” equity weight displayed in the worksheet – we return to that later.

STEP 5: You must now use these weights to calculate *equity-weighted* incremental health benefits (C22:E31) and *equity-weighted* health opportunity costs (H2:J31) associated with each of the three comparisons of policy options. Each of these is calculated by multiplying the respective *unweighted* incremental health benefits and *unweighted* health opportunity costs (both contained in the previous <Input data> worksheet) by the respective social factor equity weights (contained in cells C6:C15 of this <Equity weights> worksheet). *Hint:* Using a $ sign to fix the relevant columns and rows will make it easier to do this – you then only have to enter the calculation in the first row and can pull down to fill out the remaining rows. At this stage you do not have to worry about adding in further multiplicative factor for the “behavioural factor” equity weight – that slightly more complicated calculation is shown in the solution file, and we will come to that later.

You should then see the following results for the equity-weighted health benefits:

|  |  |  |  |
| --- | --- | --- | --- |
| Subgroup | Universal vs No NRT | Proportional Universal vs No NRT | Proportional Universal vs Universal |
| S1 - South, Most deprived fifth | 1328 | 1859 | 531 |
| S2 | 547 | 656 | 109 |
| S3 | 700 | 700 | 0 |
| S4 | 382 | 382 | 0 |
| S5 | 417 | 417 | 0 |
| N1 - North, Most deprived fifth | 3473 | 5209 | 1736 |
| N2 | 596 | 774 | 179 |
| N3 | 540 | 593 | 54 |
| N4 | 362 | 362 | 0 |
| N5 | 282 | 282 | 0 |

STEP 6: Your next task is to calculate the *equity-weighted* incremental net health benefit and *unweighted* incremental net health benefit for each social group for each of the three comparisons of policy options:

The *equity-weighted* net health benefit is calculated in C38:E47 by subtracting the equity-weighted health opportunity costs from the equity-weighted incremental health benefits.

The *unweighted* net health benefit is calculated in H38:J47 by subtracting the unweighted health opportunity costs from the unweighted incremental health benefits.

STEP 7: You can now calculate the *overall* equity-weighted incremental net health benefit and unweighted incremental net health benefit for each of the three comparisons of policy options. In each instance, the overall incremental net health benefit is the sum of the incremental net health benefit over each of the 10 social groups. These are calculated using the =SUM Excel command.

 The equity-weight net health benefit table should now look like this:

|  |  |  |  |
| --- | --- | --- | --- |
| Subgroup | Universal vs No NRT | Proportional Universal vs No NRT | Proportional Universal vs Universal |
| S1 - South, Most deprived fifth | 1256 | 1456 | 200 |
| S2 | 514 | 471 | -43 |
| S3 | 665 | 505 | -160 |
| S4 | 354 | 223 | -130 |
| S5 | 391 | 270 | -121 |
| N1 - North, Most deprived fifth | 3341 | 4469 | 1128 |
| N2 | 569 | 626 | 57 |
| N3 | 515 | 455 | -60 |
| N4 | 340 | 241 | -99 |
| N5 | 265 | 188 | -77 |
| Overall | 8211 | 8905 | 694 |

STEP 8: Interpreting the results. Which policy option is the most desirable? Let us start with the standard cost-effectiveness results before turning to the equity-weighted results. In standard CEA, consideration is made of the *unweighted* overall incremental net health benefit – i.e. the “standard net health benefit” table on the right-hand side. Look at each incremental policy comparison in turn, focusing on the key result in the “overall” row (i.e. cells H48, I48 and J48).

1. If the value in cell H48 is positive, this means that ‘universal NRT’ is preferred to ‘no NRT’; if negative, ‘no NRT’ is preferred to ‘universal NRT’;
2. If the value in I48 is positive, ‘proportional universal NRT’ is preferred to ‘no NRT’; if negative, ‘no NRT’ is preferred to ‘proportional universal NRT’;
3. If the value in J48 is positive, ‘proportional universal NRT’ is preferred to ‘universal NRT’; if negative, ‘universal NRT is preferred to ‘proportional universal NRT’.

In this analysis, H65 and I65 are both positive, while J69 is negative. This means that the preferred policy option in a standard cost-effectiveness analysis is ‘universal NRT’.

Now let us compare the DCEA results. In DCEA, consideration is made of the *equity-weighted* incremental net health benefits – the table on the left-hand side. The key overall results are in cells C48, D48 and E48.

1. If the value in cell C48 is positive, ‘universal NRT’ is preferred to ‘no NRT’; if negative, ‘no NRT’ is preferred to ‘universal NRT’;
2. If the value in D48 is positive, ‘proportional universal NRT’ is preferred to ‘no NRT’; if negative, ‘no NRT’ is preferred to ‘proportional universal NRT’;
3. If the value in E48 is positive, ‘proportional universal NRT’ is preferred to ‘universal NRT’; if negative, ‘universal NRT is preferred to ‘proportional universal NRT’.

In this analysis, *given the equity weights specified earlier*, C48, D48 and E48 are all positive. This means that the preferred policy options in this DCEA is ‘proportional universal NRT’ – a different conclusion from a standard cost-effectiveness analysis. Why is that? And what happens if we change the direct equity weights (the values in C6:C15)? Try entering some different weights and see what happens to the results in cells C48, D48 and E48. What happens if the weights are all set to 1?

STEP 9: Different equity weights can give rise to a different policy option appearing desirable. You can test this for yourself by returning to the table of equity weights and lowering the equity weight for the N1 and S1 social groups (cells C21 and C26) from 3.0 to 1.1 while leaving all the other weights at 1.

Whilst the *unweighted* incremental net health benefits are not affected by this, the *equity-weighted* incremental net health benefits have now changed for the N1 and S1 social groups, which also affects the overall estimates. Critically, the value in cell E48 is now negative, where previously it was positive. The reduction in the equity weight for the N1 and S1 social groups has thus resulted in ‘proportional universal NRT’ no longer being preferred to ‘universal NRT’. Why do you think this is the case?

Before continuing, reset the equity weights for N1 and S1 to 3.0 as they were originally.

Your next task is to plot results on the equity-efficiency impact plane. This allows for a graphical interpretation of which policy option is the most desirable.

STEP 10: Select the <Equity impact plane> worksheet. In the equity-efficiency impact plane you will plot in this exercise, the vertical axis shows the *unweighted* overall ‘incremental net health benefit’; i.e. the result of the conventional cost effectiveness analysis, while the horizontal axis shows the ‘incremental equity benefit’, in each case compared to the ‘no NRT’ policy option. Both axes use the same units (HALYs). The ‘incremental equity benefit’ (horizontal axis) represents the *difference* between the unweighted overall incremental net health benefit (vertical axis) and the equity-weighted overall incremental net health benefit.

It follows that the *sum* of the two axes represents the *equity-weighted* overall incremental net health benefit. A decision maker who wishes to enact policies that maximize the equity-weighted overall incremental net health benefit would therefore plot linear indifference curves across the plane, sloping down from top-left to bottom-right at a -45 degree angle, such that every HALY gained on the horizontal axis is exactly offset by one HALY forgone on the vertical axis (and *vice versa*). Indifference curves towards the top-right of the plane are preferred to those towards the bottom-left, such that the most preferred policy option lies on the highest indifference curve.

Your task is to calculate the data points that will be used to plot each policy option. Start by completing the table of incremental impacts compared with No NRT. The left-hand column values showing the impacts of No NRT compared with No NRT are, by definition, zero, and are already entered. You must complete the next two columns, as follows:

1. First, copy across the relevant overall results from the tables of incremental net health benefits in the <Equity weights> sheet. Pay careful attention to which cells report *unweighted* values and which report *equity-weighted* values, and ensure you choose the column corresponding to the correct policy option when compared to ‘No NRT’. *Hint:* for cell I5 in <Equity Impact Plane> worksheet, showing the standard net health benefit of ‘Universal NRT’ compared with ‘No NRT’, you should set this equal to cell H48 in the <Equity Weights> worksheet, since this reports the *unweighted* estimate for the ‘Universal NRT’ vs ‘No NRT’ comparison.
2. Second, calculate the incremental equity benefits by subtracting the unweighted net benefit from the equity-weighted net benefit. For example, the formula in cell I7 should be I6-I5.

The table should now look like this:

|  |  |
| --- | --- |
| **Impacts of each option compared with baseline No NRT** |  |
|   | No NRT | Universal NRT | Proportional Universal NRT |
| Standard net health benefit("efficiency impact") | 0 | 5146 | 4955 |
| Equity-weighted net health benefit ("social welfare impact") | 0 | 8211 | 8905 |
| Incremental equity benefit ("equity impact") | 0 | 3065 | 3950 |

For your convenience, the equations used to calculate the data points used to plot a single indifference curve through the ‘No NRT’ strategy have already been entered for you. These data have also already been added to the figure.

 At this point, the three policy options should be visible on the equity impact plane, with an indifference curve passing through ‘No NRT’. Before continuing, ensure that the table of equity weights in <Equity Weights> worksheet still reflects the table provided above (such that social groups N1 and S1 each have a weight of 3.0 and all other social groups have a weight of 1.0).

On the equity impact plane, you should see a black point at the origin (0,0), representing the ‘No NRT’ policy. The continuous black line passing through this option represents just one of an infinite set of indifference curves. This specific indifference curve denotes all points on the plane with the same *equity-weighted* overall incremental net health benefit as the ‘No NRT’ policy.

Above the black line you should see two grey points – a dark grey point, representing ‘Universal NRT’, and a light grey point, representing ‘Proportional Universal NRT’. Since both points lie above the indifference curve, they are both preferred to ‘No NRT’. They are also both “win-win” options compared with ‘No NRT’ – i.e. they yield a larger efficiency impact (the unweighted net health benefit on the vertical axis) and also a larger equity impact (the incremental equity benefit on the horizontal axis).

The dark and light grey points are quite close together in this version of the equity-efficiency impact plane. The light grey point is in fact *lower* on the plane than the dark grey point, as well as being further to the right, although this is difficult to see visually. This implies that the ‘Proportional Universal NRT’ policy would *not* be preferred to the ‘Universal NRT’ policy in a standard cost-effectiveness analysis – it has a lower unweighted net health benefit. You can confirm this numerically by looking at the relevant numerical values in the table of incremental impacts: the standard (unweighted) net health benefit value in cell J5 (the vertical axis value of ‘Proportional Universal NRT’) is lower than that in cell I5 (the vertical axis value of ‘Universal NRT’). However, there is a trade-off – although ‘Proportional NRT’ has a smaller net health benefit, it has a larger equity benefit. To see this trade-off more clearly in the equity-efficiency impact plane, however, we need to re-draw the figure to zoom in more closely. We will do this in the next step.

STEP 11: Select the <Equity impact plane 2> worksheet. This worksheet shows a re-drawn version of the same equity-efficiency impact plan, which zooms in to the North-East quadrant to provide a closer look at the comparison between ‘Universal NRT’ and ‘Proportional Universal NRT’. To save time, the calculations have been done for you. The dark grey dotted line picks out another of the infinite set of -45 degree indifference curves, except this one denotes all points on the plane with the same equity-weighted overall incremental net health benefit as the ‘Universal NRT’ policy. Above the dark grey line you should see a light grey point, representing the ‘Proportional Universal NRT’ policy. Since this point lies above the dark grey indifference curve, it follows that the ‘Proportional Universal NRT’ policy is *preferred* to the ‘Universal NRT’ policy. This preference is sensitive to the equity weights specified earlier.

STEP 12: Select the <Equity Impact Plane 3> worksheet. This worksheet shows a third version of the same equity-impact plane, this time zooming out again in order to show indifference curves passing through all three strategies – including a light grey line representing the indifference curve for the ‘Proportional Universal NRT’ policy. The light grey indifference line (‘Proportional Universal NRT’) is much closer to the dark grey indifference line (‘Universal NRT’) than the black indifference line (‘No NRT’). This indicates that the difference in equity-weighted overall incremental net health benefit between ‘Proportional Universal NRT’ and ‘Universal NRT’ is much smaller than that between ‘Universal NRT’ and ‘No NRT’.

We will now consider the policy implications of specifying different equity weights, and see how these change the results as plotted in <Equity Impact Plane 3>.

1. Return to the table of equity weights (C6:C15) in the <Equity Weights> worksheet, and increase the weight for the N1 and S1 social groups to 5.0, keeping all other weights at 1.0. This higher weight causes the indifference curves in the equity impact plane on the <Equity Impact Plane 3> worksheet to move further apart, implying that ‘Proportional Universal NRT’ is now *even* *more strongly preferred* as a policy option. Why would an increase in the equity weight applied to the N1 and S1 social groups favour ‘Proportional Universal NRT’ relative to the other policy options?
2. Next, return to the table of equity weights and set the weight for the N1 and S1 social groups to 1.0. Since all social groups now have a weight of 1.0, this is equivalent to not applying any equity weights at all. Now look at the equity impact plane – all policy options are plotted along the vertical axis, implying that there is no incremental equity benefit to any policy option. It follows that the decision maker’s policy preference is determined solely by the *unweighted* overall incremental net health benefit (i.e. on the basis of a standard cost-effectiveness analysis *only*). Since the dark grey point is the highest, this implies that ‘Universal NRT’ is now the preferred policy option.
3. Return to the table of equity weights and change the weight for the N1 and S1 social groups to 1.4, keeping all other weights at 1.0. Notice that the light and dark grey indifference curves on the equity impact plane now (almost) overlap – this implies that the decision maker is now (almost) *indifferent* between the ‘Universal NRT’ and ‘Proportional Universal NRT’ policy options, since each provides (almost) *identical* equity-weighted overall incremental net health benefit. It follows that lowering the equity weight for the N1 and S1 social groups below 1.4 (while keeping all other equity weights at 1.0) will result in the ‘Universal NRT’ policy option being preferred, while raising this equity weight above 1.4 will result in the ‘Proportional Universal NRT’ option being preferred – try this out yourself.

As an interesting thought experiment, we will briefly consider the implications for policy if the decision maker were to have *malevolent* preferences, such that they wish to do *harm* to the most disadvantaged groups:

1. Change the equity weight for the N1 and S1 social groups to -5.0, keeping all other weights at 1.0. Notice how the light and dark grey points on the equity impact plane now lie to the left of the vertical axis, implying a *negative* incremental equity benefit for each. These policy options still provide greater health benefits to the least advantaged social group when compared to ‘No NRT’; the decision maker just assigns negative value to these health benefits. As a result, the most preferred policy option is now ‘No NRT’, which now lies on the *highest* indifference curve, while the least preferred policy option is now ‘Proportional Universal NRT’. This is because such a negative weight is assigned to health benefits for patients in the least advantaged social group that the decision maker would prefer to adopt the *least* cost-effective policy option (‘No NRT’).
2. Now change the equity weight for the N1 and S1 social groups to -2.0, keeping all other weights at 1.0. This weight implies that the decision maker is still malevolent, but less malevolent than before. In this case, the preferred strategy changes to ‘Universal NRT’ – although its equity impact is given *negative* value by the decision maker, it is so much more cost-effective than ‘No NRT’ (as represented by the difference on the y-axis) that it nevertheless lies on a higher indifference curve than ‘No NRT’. However, the ‘Proportional Universal NRT’ policy option remains the least favoured, despite being more cost-effective than ‘No NRT’. Why do you think this is?
3. Lastly, consider an equity weight for the N1 and S1 social groups of -1.0 (still malevolent, but less so than in the previous two examples). In this example, ‘No NRT’ returns to being the least favoured policy option – although the equity impact of ‘Proportional Universal NRT’ is given negative value by the decision maker, it is sufficiently more cost-effective than ‘No NRT’ that it now lies on a higher indifference curve.

Although malevolent preferences provide for an interesting thought experiment, how realistic do you think such preferences are in real world practice? Would it be appropriate to instead assign a negative HALY weight to the *most advantaged* social group? Does your answer also apply to HALY weights that are less than 1 but greater than zero?

The exercise is now complete. However, as an optional additional step, you may consider the implications of applying a ‘condition specific’ HALY weight (cell H6 in the <Equity Weights> worksheet). This HALY weight is applied to all patients with the condition in question (smoking), regardless of the policy option. In order to apply this weight, edit each of equity weighted health benefit cells C22:E31 and multiply the existing formula by the value in cell H6 (you may be able to use the $ symbol to avoid editing every cell individually). And do the same for the equity weighted health opportunity costs cells. After doing this, reset the HALY weights in C21:C30 to those in the table above (i.e. a weight of 3.0 for social groups N1 and S1 and a weight of 1.0 for all other social groups), and set the ‘condition specific’ equity weight in H21 to 0.9 (implying that HALYs for smokers have only 90% of the value to the decision maker as HALYs for other conditions). Which policy is the most preferred? Now try reducing the weight in H21 to 0.8, then to 0.7, and so on down to zero. What are the policy implications of reducing this weight? Can you explain why this is?

If you have any additional time after completing the optional step above, you can experiment with different HALY weights and observe the implications on the equity-efficiency impact plane. Until now we have applied different weights to the N1 and S1 social groups only, but you may wish to apply different combinations of weights across multiple social groups. Can you explain the policy implications of each combination of equity weights by considering how the unweighted incremental health benefits and health opportunity costs are distributed across the social groups? How do equity weights applied to each of the social groups interact with the ‘condition specific’ weight in cell H6?

Finally, can you think of any problems or limitations associated with any of the equity weights applied in this exercise, in particular the ‘condition specific’ weight applied in cell H6?