Clarifying meanings of absolute and proportional shortfall with examples

1. Context

There appeared to be some confusion at the Value-Based Pricing Methods Group working party meeting on 19th July around the concept of proportional shortfall and its relation to absolute shortfall. In particular the question was raised about the starting point for the concept of proportional shortfall, i.e. should it start at the current point in the life of the patient or be some sort of lifetime concept?

This notes seeks to clarify for Methods Group members:

- Definitions of the approaches using one of the Decision Support Unit (DSU) diagrams;
- The rationale for absolute and proportional approaches;
- Illustrative examples.

Where appropriate we have also made reference to the "fair innings" and "end of life" concepts.

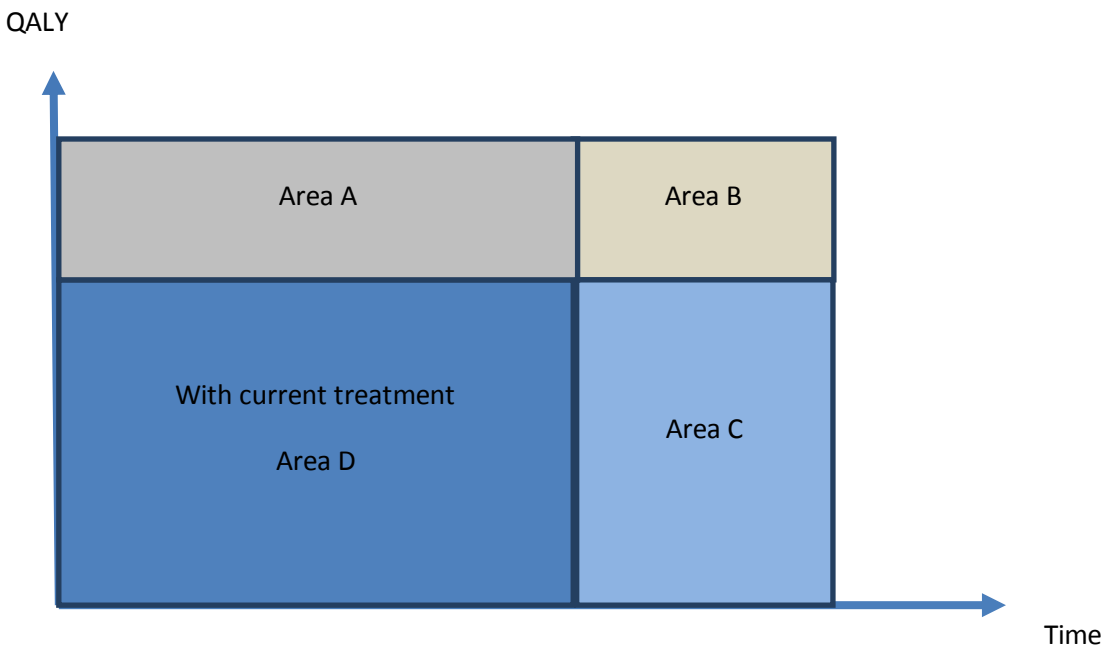
2. Definitions

To recap the definitions as set out in the DSU we use Figure 1 from the DSU paper (reproduced below).

Absolute QALY shortfall is total potential health going forwards (Areas A+B+C+D) minus current health prospects (Area D), i.e. Areas A+B+C.

Proportional QALY shortfall is the ratio of health lost to total potential health going forwards, i.e. Areas A+B+C as a proportion of Areas A+B+C+D. Importantly, the DSU note pointed out that proportional shortfall equated "relative future health gains".

Figure 1



Fair Innings (Proportional QALY shortfall from birth) is not shown in Figure 1. It would involve calculating the profile of health from birth for each individual, i.e. it includes both past health losses - not shown in Figure 1 – as well as prospective health losses and relating them to total potential lifetime health.

3. Rationale

Gavin Roberts of the Department of Health defines **absolute shortfall** approach as follows:

"The [absolute shortfall] Burden of Illness of a patient is defined as the total amount of future health they are expected to lose as a result of their condition. This could be measured in QALYs lost, in comparison to their expected future health if they did not have the condition."

Roberts argues that:

"The rationale behind this approach is simply that society cares about the absolute loss of quality of life and duration of illnesses. That is, larger losses of quality of life are more important than smaller losses. Longer durations of disease are more important than shorter durations of disease. Diseases which cause very premature death are more important than those which cause less premature death."

Stolk et al (2004), the authors who developed the concept of proportional shortfall, define the **proportional shortfall** approach in the following way:

"Proportional shortfall assumes that measurement of inequalities in health should concentrate on the fraction of QALYs that people lose relative to their remaining life expectancy, and not on the absolute number of QALYs lost or gained. It is the ratio of QALYs lost over the QALYs remaining."

They support this formulation of the burden of illness on the following grounds:

"The trouble with the [absolute shortfall] approach may be that substantial differences in health prospects may exist not only because of different illnesses, but also because of age differences. Hence, unequal health prospects may not always be considered unfair and inequitable."

Proportional shortfall combines absolute shortfall with some of the benefits of the fair innings approach, in that it is capable of recognising severity of illness in elderly populations, whereas absolute shortfall will automatically treat sufficiently elderly patients as lying at or near the bottom of the burden of illness scale, regardless of their current prognosis and regardless of their previous experience of poor health.

4. Illustrative Examples

For ease of illustration we assume (i) that QoL without the condition would be full health, i.e 1. and (ii) that the QALY weights are in linear proportion to the measure of severity adopted, i.e a patient with twice the measure of severity (whichever one is chosen) will attract a QALY multiplier which is

twice as high. In practice NICE could choose a different set of tariffs (weights) – for example to dampen down the effects – but that is not an issue for this note.

Table 1: Two individuals, Patients A and B

Individual	Age now	With current treatment QoL	With current treatment LoL	With current treatment Total QALYs (Area D)	Life expectancy without the condition	QoL without the condition	Potential QALYs in absence of the disease (Areas A+B+C+D)	Absolute QALY shortfall (A+B+C)
A	57	0.5	3	1.5	82.5	1.0	25.5	24
B	77	0.5	3	1.5	82.5	1.0	5.5	4

Absolute QALY shortfall

This is as set out in the column, 24 QALYs and 4 QALYs respectively for patients A and B, giving a respective ratio of 16.7% or 6, i.e. patient A gets a BoI weight of six times that of patient B.

Proportional QALY shortfall

This is the ratio of QALYs lost (QALY shortfall) to total QALYs, which is 24/25.5 for patient A (94%) and 4/5.5 (73%) for patient B so the ratio is 1.29, i.e. Patient A gets a BoI weighting that is approximately 30% higher than Patient B.

Concern was raised at the July meeting that the proportional shortfall gave very high weights to patients at the end of life. The proportional shortfall will tend towards one as a patient gets closer to imminent death, (i.e. as D tends to zero so (A+B+C) tends to (A+B+C+D) but it can never go above 1.[1] Thus in the example above, if Patient B had a different condition and faced imminent death and so had a proportional shortfall of 1, the ratio would switch from the younger Patient A getting a 30% higher weighting to Patient B having a higher weighting of 6.25% (1:24/25.5) We should note that in most cases, subject to the two examples which follow, proportional shortfall measures are, like absolute shortfall, decreasing in the age of the patient, i.e. the older patient the lower the weighting.

Fair Innings (Proportional QALY shortfall from birth)

This is not shown in the Figure or the Table which are both based on looking forward. However, we can illustrate the concept as follows:

Assume that both A and B were in perfect health until their current age so a fair innings weight would show:

- Total life time QALYs for both at full health = 82.5
- Total QALYs expected from birth given current treatment.
    - Patient A = (57 + 1.5) QALYs = 58.5 QALYs, shortfall 24 QALYs
    - Patient B = (77 + 1.5) QALYs = 78.5 QALYs, shortfall 4 QALYs

[1] We should note that the proportional QALY shortfall is sometimes defined as D/ (A+B+C+D) (including at one point in the DSU paper). This implies that as the patient gets closer to a premature death the BoI weighting tends towards zero which does not make sense, so we ignore this version.

In this case proportional shortfall is calculated in relation to total lifetime potential QALYs, i.e. 24/82.5 for Patient A and 4/82.5 for Patient B. The ratio is back to six to one.

If Patient B had experienced much poorer health than Patient A the ratio would fall, conversely if Patient A had a record of poor health, whereas Patient B had been healthy until they reached their current age, the ratio would increase. Thus Fair Innings can be very roughly approximated to absolute QALY shortfall except that:

- Where a younger patient has endured a much poorer QoL as compared to an older patient the weighting given by the absolute QALY shortfall would *increase*
- Where the older patient has endured a much poorer QoL the position reverses and *the older patient could even get a higher weighting.* For example, 77 years at 0.5 QoL gives an extra (past) absolute QALY shortfall of 38.5 years to add to the forward shortfall of 4 QALYs. The BoI weighting is now 24/(4+ 38.5) = 0.56, or 1.77 weighting in favour of the older patient.

A more extreme case

To more sharply show the difference between the two approaches (absolute and proportional shortfall) we assume that patients A and B have the same chronic disease which substantially reduces quality of life but does not reduce life expectancy. The difference is that one is young (aged 20) and one is old (aged 85).

Table 2: Two individuals, Patients A and B

Individual	Age now	With current treatment QoL	With current treatment LoL	With current treatment Total QALYs (Area D)	Life expectancy without the condition	QoL without the condition	Potential QALYs in absence of the disease (Areas A+B+C+D)	Absolute QALY shortfall (A+B+C)
A	20	0.5	70	35	90	1.0	70	35
B	85	0.5	5	2.5	90	1.0	5	2.5

Absolute QALY shortfall

This is 35 QALYs and 2.5 QALYs respectively for patients A and B, giving a respective ratio of 14, i.e. patient A gets a BoI weight of 14 times that of patient B.

Proportional QALY shortfall

35/70 for patient A (50%) and 2.5/5 (50%) for patient B so the ratio is 1, i.e. Patient A gets a BoI weighting that is identical to that of Patient B.

Fair Innings (Proportional QALY shortfall from birth)

This depends on the lifetime medical history of patients A and B.

1. If patient B had suffered from the same condition as patient A throughout their life, then their fair innings multiplier would be identical to the proportional shortfall ratio of 1;
2. If both patient A and patient B had only just developed the quality of life reducing condition and been in full heath until that point then the difference in fair innings QALYs would be equal to the absolute shortfall case.

Replicating the previous example for length instead of quality of life

We achieve similar results if we consider two patients of different ages who have lost equal proportions of their life expectancy.

Table 3: Two individuals, Patients A and B

Individual	Age now	With current treatment QoL	With current treatment LoL	With current treatment Total QALYs (Area D)	Life expectancy without the condition	QoL without the condition	Potential QALYs in absence of the disease (Areas A+B+C+D)	Absolute QALY shortfall (A+B+C)
A	20	1	35	35	90	1.0	70	35
B	85	1	2.5	2.5	90	1.0	5	2.5

Absolute QALY shortfall

As above, this is 35 QALYs and 2.5 QALYs respectively for patients A and B, giving a respective ratio of 14, i.e. patient A gets a BoI weight of 14 times that of patient B.

Proportional QALY shortfall

Again, as with the previous example this is given by 35/70 for patient A (50%) and 2.5/5 (50%) for patient B so the ratio is 1, i.e. Patient A gets a BoI weighting that is identical to that of Patient B.

Fair Innings (Proportional QALY shortfall from birth)

This again depends on the lifetime medical history of patients A and B.

1. If patient B had suffered from prior health problems then the fair innings multipliers would be closer to the proportional shortfall ratio of 1;
2. If both patient A and patient B had only just developed the life shortening condition and been in full heath until that point then the difference in fair innings QALYs would be equal to the absolute shortfall case.

The end of life case

If we consider two patients with the same age as above, but equalise their absolute, rather than proportional remaining QALYs then we can see how proportional and absolute shortfall function in situations similar to those which attract an end of life premium under the current system.

Table 4: Two individuals, Patients A and B

Individual	Age now	With current treatment QoL	With current treatment LoL	With current treatment Total QALYs (Area D)	Life expectancy without the condition	QoL without the condition	Potential QALYs in absence of the disease (Areas A+B+C+D)	Absolute QALY shortfall (A+B+C)
A	20	0.5	1	0.5	90	1.0	70	69.5
B	85	0.5	1	0.5	90	1.0	5	4.5

Absolute QALY shortfall

69.5 QALYs and 0.5 QALYs respectively for patients A and B, giving a respective ratio of 139, i.e. patient A gets a BoI weight of 139 times that of patient B.

Proportional QALY shortfall

69.5/70 for patient A (>99%) and 4.5/5 (90%) for patient B so the ratio is 1.1 (99%/90%) i.e. Patient A gets a BoI weighting that is 1.1 times that of Patient B.

Fair Innings (Proportional QALY shortfall from birth)

This again depends on the lifetime medical history of patients A and B.

1. If patient B had suffered from illness during their life, while patient A had been healthy, then the fair innings shortfall multiplier would move from the absolute shortfall multiplier to a value closer to proportional shortfall multiplier;
2. If both patient A and patient B had only just developed the end of life condition and been in perfect heath until that point then the difference in fair innings QALYs would be equal to the absolute shortfall case.

Final Points

It is important to accept that there is no right or wrong approach and in each of these concepts to keep separate:

- Empirical evidence of societal preferences for these concepts to be used in prioritising NHS treatments;
- Ease or difficulty of getting the data to perform the weightings;
- One's personal preferences, which are irrelevant here;
- The Terms of Reference given to NICE;
- The criteria important to the NICE Board and its Appraisal Committees.

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