RESEARCH LLC

ARTIFICIAL INTELLIGENCE LARGE LANGUAGE MODEL INTERROGATION

THE MEASUREMENT FUTURE IN HEALTH TECHNOLGY ASSESSMENT

LEGACY HTA: DECONSTRUCTING THE IMPOSSIBLE QALY

CLASS NOTES

Paul C Langley PhD Adjunct Professor, College of Pharmacy, University of Minnesota, Minneapolis, MN

LOGIT WORKING PAPER No 5989 SEPTEMBER 2026

www.maimonresearch.com

Tucson AZ

BACKGROUND

These class notes have been prepared in response to requests for a more detailed explanation of why the proportional time adjustment required to construct the QALY is impossible under the conventional approach. The issue is fundamental. The QALY has been a central feature of legacy HTA for more than 40 years, yet its status as a lawful measure of quality-adjusted time was never established before the arithmetic was adopted.

There are two principal reasons for this failure. First, legacy HTA developed without adequate recognition of the requirements of representational measurement, particularly the requirements for ratio measurement and for constructing a dimensionless proportional adjustment factor. If time is to be adjusted proportionally, the adjustment factor must have an appropriate measurement foundation; it cannot acquire that status merely because a numerical value between 0 and 1 has been assigned to it. Second, legacy HTA focused on preferences or valuations attached to multidimensional health-state descriptions rather than beginning with the measurement of defined, unidimensional attributes.

These notes are deliberately extensive. Their purpose is to take the reader step by step from the requirements of representational measurement, through ratio measurement and the construction of a lawful proportional adjustment of time, to the measurement characteristics that U would have to possess before Q = U × T could be admissible. The conventional QALY is then assessed against those requirements. Understanding this sequence is critical because the failure occurs before the QALY is calculated and therefore before any subsequent cost-effectiveness arithmetic begins. Establishing why the required time adjustment cannot be created from conventional health-state utility values is a necessary first step in abandoning legacy HTA and making the transition to an attribute-based framework grounded in lawful measurement.

1. REPRESENTATIONAL MEASUREMENT

Representational measurement begins with an **attribute**. Before numbers can be assigned and before arithmetic can be undertaken, it must be clear what characteristic of an object, event or person is intended to be measured. Measurement is not simply the assignment of numbers. It is the construction of a numerical representation of a defined empirical attribute in such a way that relevant relationships observed for that attribute are preserved in the numerical representation [1].

An attribute must be unidimensional for this purpose. This means that the measurement is directed toward one defined characteristic at a time. Time or duration is one attribute; distance is another; mass is another. For latent attributes, pain, fatigue or physical functioning may each constitute a separate attribute if each is defined and demonstrated to possess the required unidimensional structure. Different attributes cannot simply be combined into a single numerical score and then assumed to constitute a measure of some new quantity. The attribute to be measured must first be identified and its empirical structure established.

This requirement applies whether the attribute is manifest or latent. A manifest attribute is one for which quantities can be observed and measured directly against an appropriate standard. Duration provides a straightforward example. The duration of an event can be represented in seconds, hours, days or years. Distance, weight and number of treatment administrations provide other examples. In each case there is an identifiable attribute whose quantities can, subject to the appropriate measurement conditions, be represented directly.

A latent attribute presents a different measurement problem. Pain, fatigue, physical function, treatment satisfaction or need fulfilment cannot be observed directly in the same way as elapsed time or distance. The attribute must first be defined and a measurement structure created from observable responses or behaviors that provide evidence of possession of that latent characteristic. The fact that responses have been assigned numbers does not itself establish measurement. The resulting scale must satisfy the requirements necessary to demonstrate that a single latent attribute has been measured.

The distinction between manifest and latent attributes therefore concerns how measurement is achieved, not whether measurement standards are required. In both cases, the objective is to construct a numerical representation of one defined attribute whose empirical relationships are preserved by corresponding numerical relationships.

This is the central idea of representational measurement. If one object possesses more of an attribute than another, the numerical representation must preserve that ordering. If equal differences or proportional relationships are claimed, the measurement structure must justify those interpretations. Numbers have quantitative meaning only to the extent that the empirical structure of the attribute supports the corresponding numerical structure.

This immediately places a constraint on arithmetic. Arithmetic operations are not justified merely because numerical values are available. The quantities entering an arithmetic relationship must represent defined attributes, and the measurement scales representing those attributes must support the proposed operation [2]. Addition, subtraction, multiplication and division make different demands upon measurement. An operation that is meaningful for one scale may be meaningless for another.

Unidimensionality is therefore prior to arithmetic**.** Before asking whether two numbers may legitimately be multiplied or divided, we must know what each number measures. We must know the attribute represented by each quantity, whether that attribute has been established as unidimensional, what type of measurement scale has been created, and whether the proposed arithmetic is admissible for those scales and dimensions.

This can be summarized as a sequence:

Define the attribute → establish unidimensionality → establish measurement → identify the scale → determine admissible arithmetic.

The sequence cannot legitimately be reversed. We cannot begin with a desired arithmetic operation and then assume that the numbers supplied to it possess whatever measurement properties the operation requires. Nor can subsequent modelling or statistical manipulation manufacture those properties. Measurement must precede arithmetic**.**

This principle provides the starting point for considering the adjustment of time. We begin not with an equation that we wish to calculate, but with the attribute that we intend to adjust. That attribute is **time**. We must first establish how time is measured, what scale represents it, and what properties an adjustment factor must possess before it can lawfully be used to modify a measured quantity of time.

2. THE ATTRIBUTE OF INTEREST: TIME

Suppose the attribute we wish to measure is duration, represented by time T.

We are interested in quantities such as:

$$T_0 = 12 \text{ months}$$

and

$$T_1 = 6 \text{ months}$$

These are quantities of the same attribute. They are therefore commensurable: both represent duration and can be expressed in a common unit of time.

Our immediate objective is not to value health or construct a QALY. It is simply to determine how one quantity of time can be proportionally adjusted to another.

3. THE REQUIRED ADJUSTMENT FACTOR

Suppose we want to adjust an observed duration $T_0$to an adjusted duration T_A:

$$T_A = AT_0$$

where $A$is the adjustment factor.

If the adjustment is restricted to reducing or leaving unchanged the original duration, then:

$$0 \leq A \leq 1$$

For example:

$$A = 1$$

means no adjustment;

$$A = 0.5$$

means the adjusted duration is one-half of the original duration; and

$$A = 0$$

means zero duration remains.

But simply selecting a number between 0 and 1 does **not** establish a lawful proportional adjustment. The value of Amust itself have an empirical measurement interpretation that justifies its use as a multiplier of time.

4. THE RATIO SCALE

A ratio scale is a quantitative measurement scale possessing equal units and a non-arbitrary zero, such that ratios between measured quantities have empirical meaning.

Its admissible transformations are similarity transformations:

$$T' = aT,\ a > 0$$

Changing from months to days or years changes the numerical representation but preserves ratios between durations.

Thus, if:

$$T_0 = 12 \text{ months}$$

and

$$T_A = 6 \text{ months}$$

then:

$$\frac{T_A}{T_0} = \frac{6}{12} = 0.5$$

Changing units does not alter that relationship:

$$\frac{0.5 \text{ years}}{1 \text{ year}} = 0.5$$

The statement that one duration is one-half of another therefore has invariant empirical meaning.

5. CONSTRUCTING THE PROPORTIONAL ADJUSTMENT FACTOR

We can now define the required adjustment factor rather than merely assigning it:

$$A = \frac{T_A}{T_0}$$

Because numerator and denominator are commensurable quantities of the same ratio-measured attribute where [ ] denote the dimension of a quantity:

$$[A] = \frac{[T]}{[T]} = 1$$

so $A\ \ is$ dimensionless.

But its significance is not merely that it is dimensionless. It is a dimensionless proportional factor constructed from two commensurable ratio measures of time.

Consequently:

$$T_A = \left(\frac{T_A}{T_0}\right) T_0$$

is lawful.

This gives us a very important distinction:

$$\boxed{\text{A number between 0 and 1 is not necessarily a proportional adjustment factor.}}$$

For a number to serve as a lawful proportional adjustment to time, its measurement provenance must justify that interpretation.

6. TIME SPACE

If the attribute we wish to adjust is time, then the proportional adjustment factor should first be defined within the measurement domain of time itself. We will call this domain time space.

Time space is the measurement domain containing quantities of the attribute time that have been represented on a common ratio scale. A duration of 6 months and a duration of 12 months are both quantities within time space. They possess the same measured characteristic: time.

We can indicate this characteristic symbolically by writing:

$$[T]$$

The dimensional notation $[T]$simply tells us that the numerical quantity concerned represents the attribute **time**. Thus:

$$T_0 = 12 \text{ months } [T]$$

and:

$$T_1 = 6 \text{ months } [T]$$

Both quantities belong to time space. They are measurements of the same attribute and are therefore commensurable. Toi make the key point again.

Suppose we want to express T_1as a proportion of T_0. We form the ratio:

$$A = \frac{T_1}{T_0}$$

In terms of their measurement characteristic:

$$[A] = \frac{[T]}{[T]} = 1$$

The two $[T]$terms cancel because both numerator and denominator possess the same characteristic of time. We therefore describe the resulting ratio as dimensionless.

For example:

$$A = \frac{6 \text{ months}}{12 \text{ months}} = 0.5$$

The units cancel:

$$\frac{\text{months}}{\text{months}} = 1$$

and the time dimension cancels:

$$\frac{[T]}{[T]} = 1$$

leaving the dimensionless number:

$$A = 0.5$$

This does not mean that the number 0.5 has appeared without a measurement basis. Quite the opposite. We know precisely where it came from. It was created by taking the ratio of two commensurable ratio measures within time space.

The value 0.5 therefore has a defined proportional interpretation:

$$T_1 = 0.5T_0$$

or equivalently:

$$\frac{T_1}{T_0} = 0.5$$

It tells us that one measured duration is one-half of another measured duration.

This gives us the adjustment factor required to adjust time:

$$T_A = AT_0$$

where:

$$A = \frac{T_1}{T_0}$$

The essential point is that the proportional adjustment factor for time has been constructed within time space from two ratio measures of the same attribute. Its dimensionless status is the consequence of dividing time by time; it is not a property acquired merely because the resulting number happens to lie between 0 and 1.

7. QALITY ADJUSTED TIME

The QALY is intended to create a quantity of quality-adjusted time. It begins with a measured duration of time and applies a numerical adjustment intended to reflect the preference or desirability attached to the health state experienced during that period.

The familiar QALY expression is:

Q = U × T

where:

Q = quality-adjusted time

U = health-state utility or preference value

T = measured duration of time

The construction appears straightforward. If one year is lived in a health state assigned a utility value of 1.0:

Q = 1.0 × 1 year = 1.0 QALY

If one year is lived in a health state assigned a utility value of 0.5:

Q = 0.5 × 1 year = 0.5 QALYs

Similarly, twelve months at U = 0.5 gives:

Q = 0.5 × 12 months = 6 quality-adjusted months

The numerical effect of the QALY construction is therefore to use U as an adjustment factor applied to time. A value of U = 1 leaves the measured duration unchanged. A value of U = 0.5 reduces it by one-half. A value of U = 0.8 reduces it to eight-tenths of its original value.

The critical question is therefore:

What has been measured to create the adjustment factor U?

Unlike time, U is not obtained by directly measuring a single manifest attribute such as duration. Conventional QALY utilities originate in descriptions of health states. These health states are typically composite and multidimensional. They may incorporate mobility, self-care, usual activities, pain or discomfort, anxiety or depression, and other characteristics.

Preferences are then elicited for these composite health states. Techniques such as time trade-off and standard gamble, or valuation models derived from such exercises, assign numerical values to them. These values are conventionally placed on a scale in which full health is assigned the value 1 and dead the value 0, while some health states may receive values below zero.

The resulting value U is therefore a preference or desirability value attached to a composite multidimensional health state. It is not constructed from two measured quantities of time.

Nevertheless, when the QALY is calculated, U is required to perform a very specific arithmetic role. It is used as a multiplicative adjustment factor for ratio-measured time:

$$\mathbf{Q = U \times T}$$

Consider:

$$\mathbf{U = 0.5}$$

and:

$$\mathbf{T_0 = 12 \text{ months}}$$

The QALY calculation gives:

$$\mathbf{Q = 0.5 \times 12 \text{ months} = 6 \text{ quality-adjusted months}}$$

The value U = 0.5 is therefore being used as though it establishes the proportional time relationship:

$$\mathbf{T_1 / T_0 = 0.5}$$

or:

$$\mathbf{6 \text{ months} / 12 \text{ months} = 0.5}$$

But U = 0.5 was not created from:

$$\mathbf{T_1 / T_0 = 6 \text{ months} / 12 \text{ months}}$$

It originated as a numerical preference or desirability value assigned to a composite health state.

We therefore have two different constructions.

Within time space, a proportional adjustment factor can be defined as:

$\mathbf{A_t = T_1 / T_0}$

For example:

$\mathbf{A_t = 6 \text{ months} / 12 \text{ months} = 0.5}$

Because both quantities possess the attribute of time:

$\mathbf{[A_t] = [T] / [T] = 1}$

The time dimensions cancel. The resulting value is dimensionless, but its empirical meaning is clear: **T_1 is one-half of T_0**.

The conventional QALY substitutes a different value:

$\mathbf{A_t = U}$

so that:

$\mathbf{T_1 / T_0 = U}$

For U = 0.5, this requires:

$\mathbf{T_1 / T_0 = U = 0.5}$

This is the measurement proposition on which the quality adjustment of time depends.

The question that must therefore be answered **before the multiplication is undertaken** is:

What characteristics must the preference or desirability value U possess if it is to serve as a lawful proportional adjustment factor for ratio-measured time?

The fact that U is represented by a number between 0 and 1 cannot itself establish those characteristics. They must be demonstrated through representational measurement before U can legitimately be used to adjust time.

8. REQUIRED CHARACTERISTICS OF U

The QALY requires the health-state value **U** to perform a specific function. It must operate as a **proportional adjustment factor for ratio-measured time**.

The starting expression is:

$$\mathbf{Q = U \times T}$$

If:

$$\mathbf{U = 0.5}$$

then the QALY construction requires U to reduce the measured duration by one-half. In terms of time, this requires:

$$\mathbf{T_1 / T_0 = 0.5}$$

More generally, the QALY requires:

$$\mathbf{T_1 / T_0 = U}$$

The question is therefore not whether U has been assigned a numerical value. It is whether U possesses the measurement characteristics necessary to justify this proportional adjustment of time.

A DEFINED ATTRIBUTE

Representational measurement begins with an attribute. We must therefore be able to state precisely what U measures.

If U represents preference, desirability, value or some other characteristic of a health state, that characteristic must be explicitly defined. Calling the number a "utility" does not establish the attribute being measured.

Let the proposed attribute be preference, represented by:

[P]

A numerical value U must then be a measurement of possession of that defined attribute. It cannot acquire measurement status merely because a numerical value has been assigned to a health state.

UNIDIMENSIONALITY

The attribute represented by U must be unidimensional. It must represent one defined characteristic.

If the proposed attribute is preference, the measurement system must demonstrate that U represents possession of that single preference attribute. If the proposed attribute is desirability, it must demonstrate possession of a single desirability attribute.

A collection of different health characteristics does not become a unidimensional attribute simply because they are combined into a single numerical value.

The required sequence remains:

Define the attribute → establish unidimensionality → establish measurement

Only then can the properties of the resulting numerical scale be considered.

A RATIO MEASUREMENT STRUCTURE

U is not merely being used to establish that one health state is preferred to another. Nor is it being used merely to represent a difference between health states. It is being required to make a proportional adjustment.

A proportional statement requires meaningful ratios.

Suppose two measured quantities of the preference attribute are:

P_0 and P_1

If P_1 represents one-half of P_0, then:

$$P_1 / P_0 = 0.5$$

For this statement to have empirical meaning, the preference attribute must possess a measurement structure that supports meaningful ratios.

An ordinal scale cannot provide this interpretation. An interval scale cannot provide it because its zero is arbitrary and ratios between scale values are not invariant. The required measurement structure must support meaningful proportional relationships.

For a linear ratio scale, the admissible transformation is:

$$P' = aP,\ a > 0$$

Under this transformation:

$$P_1' / P_0' = aP_1 / aP_0 = P_1 / P_0$$

The proportional relationship is therefore invariant.

A MEANINGFUL ZERO

A meaningful ratio requires a non-arbitrary zero.

If:

$$\mathbf{P_1 / P_0 = 0.5}$$

is to mean that P_1 represents one-half of P_0, the origin of the scale cannot be moved arbitrarily.

If instead the admissible transformation were that of an interval scale:

$$\mathbf{P' = aP + b}$$

then:

$$\mathbf{P_1' / P_0' = (aP_1 + b) / (aP_0 + b)}$$

which does not, in general, equal:

$$\mathbf{P_1 / P_0}$$

The ratio depends upon the arbitrary choice of origin.

Consequently, a numerical value such as:

$$\mathbf{U = 0.5}$$

cannot mean "one-half" merely because the number 0.5 appears on a scale bounded or anchored by values labelled 0 and 1. The zero must have the measurement meaning required to support proportional comparisons.

CONSTRUCTION OF A PREFERENCE ADJUSTMENT FACTOR

Suppose these requirements have been satisfied and lawful ratio measurement of the preference attribute has been achieved.

A proportional preference factor could then be constructed as:

$$\mathbf{A_p = P_1 / P_0}$$

Because P_1 and P_0 represent the same attribute:

$$\mathbf{[A_p] = [P] / [P] = 1}$$

The preference dimensions cancel and A_p is dimensionless.

For example:

$$\mathbf{P_1 / P_0 = 0.5}$$

would have a defined empirical interpretation: the measured quantity P_1 stands in a one-half relationship to the measured quantity P_0 within preference space.

This would be a lawful proportional preference factor.

It would not yet be a lawful proportional time factor.

DIMENSIONLESS DOES NOT MEAN INTERCHANGEABLE

Within time space we previously constructed:

$\mathbf{A_t = T_1 / T_0}$

with:

$\mathbf{[A_t] = [T] / [T] = 1}$

Within preference space we might, if lawful ratio measurement existed, construct:

$\mathbf{A_p = P_1 / P_0}$

with:

$\mathbf{[A_p] = [P] / [P] = 1}$

Both results are dimensionless.

Suppose:

$\mathbf{A_t = 0.5}$

and:

$\mathbf{A_p = 0.5}$

Their numerical values are identical:

$\mathbf{A_t = A_p = 0.5}$

But their empirical meanings are different.

The first means:

$\mathbf{T_1 / T_0 = 0.5}$

One quantity of time is one-half of another quantity of time.

The second means:

$$\mathbf{P_1 / P_0 = 0.5}$$

One quantity of preference is one-half of another quantity of preference.

Cancellation of dimensions does not erase the empirical origins of the two ratios. Dimensionless quantities are not automatically interchangeable merely because they have the same numerical value.

THE REQUIRED MAPPING

For a preference-derived value to adjust time, an additional relationship must therefore be demonstrated.

The QALY requires:

$$\mathbf{U = T_1 / T_0}$$

If U is derived from preference measurement:

$$\mathbf{U = P_1 / P_0}$$

then the required relationship becomes:

$$\mathbf{T_1 / T_0 = P_1 / P_0}$$

or:

$$\mathbf{A_t = A_p}$$

This equality cannot be established merely by assigning the same numerical value to both sides.

A mapping must be demonstrated from the proportional relationship in preference space to the proportional relationship required in time space:

$$\mathbf{P_1 / P_0 \rightarrow T_1 / T_0}$$

Thus, if:

$$\mathbf{P_1 / P_0 = 0.5}$$

there must be an empirical basis for concluding:

$$\mathbf{T_1 / T_0 = 0.5}$$

The fact that both ratios are dimensionless is not that demonstration.

9. THE UNLAWFUL QALY

The preceding sections establish what must be demonstrated if a health-state preference or desirability value U is to operate as a proportional adjustment factor for ratio-measured time. The requirements are not created specifically to challenge the QALY. They follow from the standards of representational measurement and from the quantitative role that the QALY itself requires U to perform.

For:

Q = U × T

to have a lawful measurement interpretation, U must satisfy the following requirements:

U must represent a defined attribute.

The attribute must be unidimensional.

The attribute must be lawfully measured.

The measurement structure must support meaningful proportional relationships.

The zero must have the measurement status required for ratio interpretation.

U must be constructed as a lawful proportional relationship within preference or desirability space.

A mapping must be demonstrated from that proportional relationship to the proportional relationship required in time space.

The conventional QALY utility fails to establish these requirements.

THE CONSEQUENCE

We can now return to the QALY expression:

Q = U × T

Time can be represented as a ratio-measured manifest attribute:

[T]

But the proposed adjustment factor U has not been demonstrated to possess the measurement characteristics required for the proportional role assigned to it.

The conventional construction simply inserts U into the multiplication:

$Q = U \times T$

and treats:

$U = 0.5$

as though it established:

$T_1 / T_0 = 0.5$

It does not.

The problem therefore occurs before the QALY is calculated. It cannot be repaired by subsequently taking differences between QALYs, constructing incremental QALYs, dividing incremental costs by incremental QALYs, discounting future QALYs, undertaking probabilistic sensitivity analysis or embedding QALYs within increasingly sophisticated decision models. Those operations all presuppose that a lawful QALY quantity already exists.

The required measurement chain has not been established:

No defined unidimensional preference attribute
→ no demonstrated ratio measurement
→ no lawful preference proportion
→ no demonstrated mapping into time space
→ no lawful proportional adjustment of time
→ no lawful QALY

The conclusion follows from the measurement requirements established before the QALY was introduced: The conventional QALY has not been demonstrated to be a lawful measure of quality-adjusted time.

There is no measurement-theoretic basis for retaining the conventional QALY as a lawfully adjusted duration of time. The failure occurs at the point of construction. It is therefore not a problem that can be repaired by modifying the QALY formula, selecting a different preference instrument, changing valuation techniques or refining the economic model in which QALYs are subsequently used.

The QALY failed the requirements of representational measurement before it was proposed as a quantitative measure. Its construction did not begin by asking what measurement properties an adjustment factor must possess if it is to modify ratio-measured time proportionally. Instead, a numerical health-state preference value was placed alongside time:

$Q = U \times T$

and multiplication was undertaken.

The measurement requirements should have been established first.

If time is the attribute to be adjusted, a proportional adjustment can be defined within time space as:

$$\mathbf{A_t = T_1 / T_0}$$

where T_1 and T_0 are commensurable ratio measures of the same attribute. Because:

$$\mathbf{[A_t] = [T] / [T] = 1}$$

the resulting factor is dimensionless. But its dimensionless status is not arbitrary. It arises because the numerator and denominator are two ratio measures of the same attribute. The factor consequently has a defined proportional interpretation within time space.

The conventional QALY utility was required to perform this same proportional role without first demonstrating the corresponding measurement properties. No defined unidimensional preference or desirability attribute was established. No lawful ratio measurement structure was demonstrated. No meaningful preference ratio was constructed. No non-arbitrary zero supporting proportional interpretation was established. And no mapping was demonstrated from a proportional relationship in preference space to the proportional relationship required in time space.

The central problem can therefore be stated simply:

A numerical health-state preference value was treated as though it were a dimensionless proportional adjustment factor for time without demonstrating the measurement structure required to give it that meaning.

THE QALY CANNOT BE RESCUED DOWNSTREAM

Once the initial multiplication is inadmissible, subsequent arithmetic cannot repair it.

If:

$$\mathbf{Q = U \times T}$$

has not created a lawful measure, then the difference:

$$\mathbf{\Delta Q = Q_1 - Q_0}$$

does not create one.

The fact that economic evaluation is comparative does not alter this conclusion. Before two quantities can be meaningfully compared by subtraction, the quantities themselves must first have been lawfully constructed. Taking the difference between two quantities whose measurement status has not been established cannot retrospectively supply the missing measurement properties.

The same problem carries directly into the incremental cost-effectiveness ratio:

ICER = ΔC / ΔQ

If ΔQ is not a difference between lawfully measured quantities of quality-adjusted time, division of incremental cost by ΔQ cannot create a scientifically meaningful cost-per-QALY ratio.

The failure therefore propagates through the entire analytical sequence:

No lawful U
→ no lawful U × T
→ no lawful QALY
→ no lawful ΔQALY
→ no scientifically meaningful cost/ΔQALY ICER

Discounting, modelling, probabilistic sensitivity analysis, scenario analysis and simulation all occur downstream of this failure. They can manipulate the numerical values supplied to them, but they cannot establish measurement properties that those values did not possess at the point of construction.

10. THE DEEPER ERROR: HEALTH STATES RATHER THAN ATTRIBUTES

Abandonment of the QALY does not, however, identify the full extent of the problem. The QALY is the most visible consequence of a more fundamental error in the development of legacy HTA. The framework focused on health-state descriptions rather than attributes.

A health state is a description or profile. It may incorporate mobility, self-care, usual activities, pain, fatigue, anxiety, depression and other characteristics simultaneously. Such a description may be clinically useful. Individuals may also express preferences between alternative health-state descriptions. Neither fact establishes that the health state constitutes a measurable unidimensional attribute.

Representational measurement requires the opposite starting point.

The first question is: What is the attribute of interest?

Only after that attribute has been defined can its measurement requirements be established.

If the attribute is manifest, such as survival duration, hospital days, walking distance or number of treatment administrations, an appropriate direct measurement pathway can be developed.

If the attribute is latent, such as pain, fatigue, physical function or need fulfilment, the latent construct must first be defined and a measurement structure created that demonstrates possession of that single attribute.

The required sequence is: **Attribute → unidimensionality → measurement → scale → admissible arithmetic → therapy-impact claim**

Legacy HTA effectively reversed this sequence. It began with multidimensional health-state descriptions, attached numerical preference values to them, called those values utilities and then used the resulting numbers in arithmetic operations required by an already specified economic framework.

That is measurement inversion.

ABANDONMENT MEANS MORE THAN REMOVING THE QALY

The implication is therefore more substantial than simply deleting the QALY from legacy HTA and the reference case.

Replacing one multiattribute preference instrument with another does not solve the problem. Changing from one elicitation technique to another does not solve it. Re-estimating value sets does not solve it. Rescaling existing utility values does not solve it. None of these changes addresses the prior requirement to define an attribute and establish lawful measurement before arithmetic is undertaken.

The transition required is from health-state valuation to attribute measurement. This is the only future for assessing therapy impacts within the standards for normal science.

For therapy-impact claims, this means identifying the specific attribute that a therapy is expected to change and selecting the measurement pathway appropriate to that attribute. Manifest attributes require appropriate linear ratio measurement. Latent attributes require a measurement system capable of constructing a unidimensional latent continuum and supporting invariant quantitative comparisons. The necessary and sufficient condition is Rasch measurement [3] .

The objective is no longer to compress multiple characteristics of health into a single preference-weighted number. It is to make empirically evaluable claims about changes in defined attributes.

THE END OF THE LEGACY SEQUENCE

The QALY cannot be retained as a lawful proportional adjustment of time because the measurement requirements necessary for its construction were never established. This is not a minor technical deficiency in an otherwise valid measure. It removes the measurement foundation for the arithmetic that follows from it.

But the more important lesson is methodological. The QALY became possible conceptually only because legacy HTA began in the wrong place. It began with health states, preferences and arithmetic rather than with attributes, measurement and admissible operations.

The required reconstruction therefore begins by reversing that sequence:

Do not begin with the QALY.

Do not begin with a utility.

Do not begin with a health-state description.

Begin with the attribute.

Once the attribute is defined, measurement can be established. Once measurement is established, admissible arithmetic can be determined. Only then can scientifically meaningful claims for therapy impact be constructed, tested, replicated and, where the evidence demands it, falsified.

For legacy HTA, therefore, abandonment of the QALY is not the end of the reconstruction; it is the beginning

11. THE TRANSITION TO LAWFUL MEASUREMENT

This is precisely why a nine-unit **Reconstructing HTA Programs: Measurement before Arithmetic** program was developed [4]. Abandoning the QALY identifies what must be removed; it does not by itself provide the measurement framework required to replace legacy HTA. The transition must therefore be constructive as well as critical.

The program provides a structured pathway from an HTA framework built around health-state descriptions, preference values, utilities, QALYs and cost-per-QALY claims to one grounded in the standards of representational measurement. It begins where quantitative science must begin: with the definition of the attribute to be measured.

From that starting point, the program establishes the distinction between manifest and latent attributes and the different measurement requirements appropriate to each. Manifest attributes require appropriate linear ratio measurement. Latent attributes require the construction of a defined unidimensional measurement structure, with Rasch measurement providing the required pathway to invariant measurement of possession of the latent attribute. Measurement properties are established before arithmetic is undertaken, and therapy-impact claims are then constructed from quantities whose measurement status and admissible operations have been explicitly demonstrated.

The sequence is therefore reversed from that of legacy HTA:

Legacy HTA: health-state description → preference value → utility → arithmetic → QALY → cost/QALY

The reconstructed sequence is:

Defined attribute → unidimensionality → measurement → scale → admissible arithmetic → therapy-impact claim → empirical evaluation → replication and falsification

This is not simply a proposal for adding several measurement topics to an otherwise unchanged HTA curriculum. The failure of the QALY demonstrates why that would be insufficient. The organizing framework itself must change. Measurement can no longer be treated as an optional preliminary topic before students proceed to the established methods of economic evaluation. Measurement becomes the gatekeeper for every subsequent quantitative claim.

The nine-unit program was developed specifically to support this transition. It provides faculty, researchers, analysts and decision makers with a teaching and research framework through which legacy methods can be evaluated against the requirements of representational measurement and replaced by claims constructed from lawfully measured attributes.

There is no scientifically defensible alternative that preserves the existing QALY framework. Once the proportional adjustment required by **Q = U × T** cannot be established, continued use of the QALY cannot be justified by convention, widespread acceptance, institutional endorsement or decades of application. Nor can increasingly sophisticated modelling compensate for the absence of lawful measurement. Now its central quantitative framework has been shown to lack the measurement foundation required for its arithmetic, continued use cannot be justified by convention, institutional endorsement, regulatory acceptance or decades of application. The consequence is not a choice between competing methodologies. It is a requirement to abandon the failed framework and reconstruct HTA so that measurement precedes arithmetic and every quantitative claim satisfies the standards of representational measurement. There is no alternative to lawful measurement.

The transition is from health-state valuation to attribute measurement; from assumed numerical properties to demonstrated measurement properties; and from measurement inversion to measurement before arithmetic.

ACKNOWLEDGEMENT

I acknowledge that I have used OpenAI technologies, including the large language model, to assist in the development of this work. All final decisions, interpretations, and responsibilities for the content rest solely with me.

ABOUT THE AUTHOR

Dr Paul Langley is a health economist. Originally from the UK, Dr Langley completed his graduate studies in Canada and has taught in the UK, Canada, Australia and the United States. After over 20 years teaching university in Australia, Dr Langley moved to take up academic positions in the United States. He now lives in Tucson, Arizona to enjoy the Catalina mountains, the Sonoran Desert, the absence of mosquitos and his swimming pool.

REFERENCES

[1] Krantz D, Luce R, Suppes P, Tversky A. *Foundations of Measurement. Vol. 1: Additive and Polynomial Representations*. New York: Academic Press; 1971

[2] Stevens S. On the Theory of Scales of Measurement. *Science*. 1946;103(2684):677–680

[3] Bond T, Zi Yan, Heene M. Applying the Rasch model: Fundamental measurement in the Human Sciences (4th Ed). New York: Routledge, 2021

[4] Maimon Research. *Reconstructing HTA Programs: Measurement before Arithmetic*. https://maimonresearch.com/hta-reconstruction-program-and-fees/