
Article:
Tsuchiya, A. orcid.org/0000-0003-4245-5399 and Watson, V. (2017) Re-Thinking 'The Different Perspectives That can be Used When Eliciting Preferences in Health'. Health Economics, 26 (12). e103-e107. ISSN 1057-9230

https://doi.org/10.1002/hec.3480

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submitted to HEL, version 3; 1 June 2016
resubmitted to HEL; version 4; 22 Nov 2016
typo corrected; version 4.1; 9 Dec 2016
main text aligned to proofs 2 Feb 2017
appendix aligned to proofs 7 Feb 2017

Re-thinking "the different perspectives that can be used when eliciting preferences in health"

Running head: Re-thinking the perspectives

Main text: 2001 words; one table; no figures

Appendix: 6291 words (including formulae); two tables; no figures

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Research funding: none
Conflict of interest: none

Acknowledgements

This paper was conceived through discussions with Donna Rowen and Mandy Ryan. Earlier versions have been presented at: Workshop on Health Equity, Montreal, April 2015; an external seminar at the University of Leeds, July 2015; an internal seminar at the University of Aberdeen, November 2015; and the Health Economists' Study Group conference, Manchester, January 2016. We would like to thank John Brazier, James Burgess, Gurleen Popli, and an anonymous reviewer for *Health Economics* for their comments. The Health Economics Research Unit is funded by the Chief Scientist office of the Scottish Government Health and Social Care Directorates. The usual disclaimers apply. The study does not involve human participants and has no research ethics approval.

Re-thinking "the different perspectives that can be used when eliciting preferences in health"

Abstract

The 2003 *Health Economics* paper by Dolan, Olsen, Menzel and Richardson on "An inquiry into the different perspectives that can be used when eliciting preferences in health" presents a conceptual framework of six perspectives along two dimensions: preferences (personal, social, and socially inclusive personal) and context (ex ante and ex post). The objective of our paper is to re-think this framework. We ask four questions concerning: the patient, or the user of the treatment; the payer of the treatment; and the assessor of the value of treatment; and the timing of the illness and the nature of its risk. These questions refine the preference and context dimensions, and leads to the identification of perspectives not classified by the original framework. We propose an extended framework with five preferences (personal, non-use, proxy, social and socially inclusive personal) and five contexts (one of which is ex post and four ex ante): since two of these cells are empty, this results in 23 possible perspectives. An appendix presents 11 of these more formally to clearly distinguish between them and uses monetary and non-monetary (time trade-off) valuation tasks as examples.

(186wds)

Key words: non-use value; proxy value; social value; monetary valuation; risk and inequality aversion

1. Introduction

The paper "An inquiry into the different perspectives that can be used when eliciting preferences in health" (Dolan et al, 2003 – hereafter, the "DOMR" paper) presents a conceptual framework of six perspectives along two dimensions: preferences (personal, social, and socially inclusive personal) and contexts (ex ante and ex post):

> "The framework has two dimensions. The first concerns whom the respondent is asked to think about. It could be that the question is concerned with: (i) the respondent herself, in which case she is being asked for her *personal* preferences; (ii) people other than the respondent, thus eliciting her *social* preferences, or (iii) both the respondent and other people, which involves the elicitation of her *socially inclusive personal* preferences. The second dimension concerns the relative point in time at which the preference is elicited and, as a result, the degree of certainty associated with the need for health care. It could be that there is uncertainty about whether or not health care will be needed in the future (referred to as the *ex ante* context) or it could be that it is known that health care is needed now (referred to as the *ex post* context)." (DOMR, p.546; emphases in original)

Empirical research on social value judgements that compares across interventions for different patient groups, and aims to elicit a social preference, has been influenced by the DOMR framework (for example, Gyrd-Hansen, 2005; Pinto-Prades, Abellán-Perpiñan, 2005; Schwappach, 2005; Dolan, Tsuchiya, 2009 – also see Gaertner, Schokkaert, 2012). However, the framework should apply to all preference elicitation exercises. These exercises should be clear about the perspective from which respondents are being asked to complete the task. For example, in a monetary valuation of a treatment, respondents can be asked for their own value for the treatment for themselves, or how much they believe each person in society should pay for a treatment to be available to others when they need it.

Our objective is to reassess the framework critically, and to illustrate its imprecision and incompleteness. First, we set the context to ex post, to examine how to distinguish between personal and social preferences, by asking three questions:

- Who is the patient, or the *user* of the treatment?
- Who is the *payer* for the treatment?
- Who is the *assessor* of the value of treatment?

Answers to these questions result in five preferences (personal, non-use, proxy, socially inclusive personal, and social) – two more than DOMR included. We then examine the ex ante context in social preferences by asking:

- What is the nature of the future illness?

Answers to this question result in five contexts (one ex post and four ex ante). Of the five-by-five matrix of possible perspectives, two of the four ex ante contexts are empty when combined with a personal preference, resulting in 23 perspectives outlined in Table 1. Consequently, in any survey a respondent may be asked to take on several roles, which have not always been explicitly defined. In the below, we illustrate our extended framework using informal examples in terms of willingness to pay (WTP). An Appendix formally presents 11 of the perspectives, using both monetary and health state valuations as examples. We use the contingent valuation method and Time Trade Off (TTO) as examples. These are stylised to emphasise what differs between perspectives. These examples can be adapted to apply to other elicitation tasks such as Discrete Choice Experiments (DCEs) or Standard Gamble (SG).

2. The ex post context

In the DOMR framework, who the *user* (or beneficiary) of the treatment is distinguishes personal and social preferences. Furthermore, an ex post personal perspective means the probability of the

respondent's own treatment need is one, while the probability that others in society need treatment is zero. In contrast, an ex post social perspective means the probability of the respondent's need is zero and the others' need is one. We argue that a personal preference requires the respondent to be the *user*, *payer* and *assessor* (see scenarios (1) and (2) in the Appendix). Between personal and social preferences, the following two preferences are missing from DOMR:

- Suppose a respondent is asked her WTP to cure an illness that she will not get (and neither will anybody close to her) – the respondent is not the *user* but is the *payer* and *assessor* (Appendix, scenarios (3) and (4)). The DOMR framework would label this a social preference, but this represents a "non-use value" or "caring externality".
- Suppose a respondent is asked to assess patients' WTP to cure an illness that the patients have – the respondent is not the *user* or *payer* (Appendix, scenarios (5) and (6)). Again, the DOMR framework would label this a social preference, but this is the respondent's estimate of other peoples' personal preferences, or "proxy values".

Furthermore, social preferences concern a social welfare function (as opposed to an individual utility function) and should be distinguished from personal preferences by the source of the value – the *assessor* – by asking respondents, for example, to imagine themselves as an officer authorised to make decisions on the population's behalf (Appendix, scenarios (7) to (13)). Such choices appeal to normative views on how society *should* operate – social value judgments – and may invoke interpersonal comparisons (Appendix, scenarios (11) and (12)) and/or evaluations of fairness (Appendix, scenario (13)). Such judgements require a detached impartial perspective, which translates to the separation of the *assessor* role from the *user* and *payer* roles.

In DOMR, a socially inclusive personal preference perspective asks respondents to consider their self-interest alongside what is best for society. In this perspective, the respondent is *one of the users*, and the users are a subset of the *payers* (Appendix, scenarios (14) and (15)).

3. The ex ante context

In the ex ante context the illness has not yet happened. DOMR defines an ex ante context as where the probability of illness is strictly less than one. For completeness, we introduce an ex ante case with no uncertainty. The ex ante personal perspective consists of: one where a respondent is asked her WTP now to treat a future illness that she will get for certain (Appendix, scenarios (16) and (17)); and one where she is asked for her WTP now to treat a future illness that she may or may not get (Appendix, scenario (18)).

Regarding the ex ante social perspective, suppose there is a 5% rate of future illness amongst 1000 people – this could mean any of the following:

Case 1: there will be exactly 50 patients for certain and we already know who they are;

Case 2: there will be exactly 50 patients for certain but we do not know who they are;

Case 3: each of the 1000 individuals have a 5% chance of becoming ill –ex post there will be *around* 50 patients; and

Case 4: there is a 5% probability that all 1000 people will become ill – ex post there will be either exactly zero or exactly 1000 patients.

Case 1 has no uncertainty (Appendix, scenario (19)). It is well known that expected utility theory (which concerns personal preferences) does not distinguish between cases 2, 3 and 4: the expected number of patients is 50. Case 2 has no risk at the collective level (there will be exactly 50 patients for certain) but ex post outcomes will be unequal across individuals (some will be ill, others will be healthy), so this can be used to elicit inequality aversion, controlling for risk (Appendix, scenario (20)). Similarly, Case 4 has no inequality across the individuals (all 1000 will have the same outcome), but there is uncertainty as to which outcome, so this can be used to elicit risk aversion at the social level, controlling for inequality (Appendix, scenario (22)). Case 3 combines risk at the collective level and inequality across individuals (Appendix, scenario (21)), therefore responses will be affected by risk

and inequality aversion. The DOMR framework that does not allow these meaningful distinctions for the ex ante social perspective is imprecise.

4. Discussion

We have critically reassessed the DOMR framework of the perspectives that can be used to elicit preferences in health, and shown that the DOMR framework is imprecise and incomplete in both the preference and context dimensions. We expand the conceptual framework to five preferences and five contexts, with 23 possible perspectives. The Appendix illustrates more formally 11 of these perspectives.

In the preference dimension, DOMR defines the difference between personal and social perspectives based on the *user* (who is or becomes ill). However, respondents can have three roles in an elicitation task: the *user*; the *payer*; and the *assessor*. It is possible to elicit personal preferences when the respondent is the *payer* and *assessor*, but not *user*, and thereby measure caring externalities. Personal-proxy assessments can be elicited when the respondent is the *assessor*, but not the *user* or *payer*. Given these, we propose two preferences to add to the three in DOMR: the non-use and the proxy. We show that social preference should be defined with respect to who the *assessor* is (respondent as a private individual versus respondent as a decision maker), and not with respect to who the *user* is.

In the context dimension, DOMR differentiates between ex ante and ex post contexts using future events that occur with probability p that is strictly less than 1. We add a perspective for future events that occur with certainty. Furthermore, across the risky ex ante social perspectives, DOMR does not refer to the independence of the probability of illness between groups. We extend the framework to distinguish between three risky contexts for a group of N individuals (who are currently healthy) with expected patient numbers of $n = pN$.

This highlights the different perspectives that are necessary to elicit inequality aversion (Case 2) or (social) risk aversion (Case 4). If an ex ante social elicitation task includes uncertainty then arguably respondents are most likely to assume Case 3 - independent probabilities – where the two aversion types are confounded.

Our extended five-by-five framework will facilitate comparisons across empirical studies with more clarity at the conceptual level, by classifying studies into one of 23 preferences. Our framework is applicable to all preference elicitation studies in health settings and beyond – it can be used to guide empirical study design, and help researchers to ensure that they have the most appropriate framework for their research question. The framework provides a set of roles the respondent can be asked to take in a preference elicitation exercise and we suggest that researchers should ensure that each role is clear at the study design stage. Our framework also clarifies the role of risk in an ex ante context.

Several of the considerations identified by O'Brien and Gafni (1996) in their conceptual framework for contingent valuation studies are reflected in our framework. O'Brien and Gafni (1996) identify both non-use values and option values as relevant preferences. They question if ex post service user's personal preferences are appropriate for cost benefit analyses of a collectively funded health care service that should take account of all benefits to society. Our framework includes non-use preferences, our extended ex ante context dimensions allow for non-use values, and our use of risk includes the range of uncertain outcomes identified by O'Brien and Gafni (1996).

Preference elicitation tasks used by health researchers originally asked for personal preferences of patients or public for their own treatment with the trade-off being in terms of own money or own health. The area of application for preference elicitation has expanded to include doctor's/carer's preferences for treatment on behalf of their patients. The type of goods being valued have expanded to include public health interventions (Edwards et al, 2013). These can be preventative rather than curative, target a broad range of outcomes, have spill over effects on non-

targeted individuals and include equity considerations. Elicitation perspectives not included in DOMR such as non-use preferences and inequality aversion are needed to value these outcomes. Our extended framework has better coverage to accommodate the expanded range of contexts in which preference elicitation is applied.

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Table 1: Summary of the 23 perspectives in terms of respondents' roles and number of persons treated

			CONTEXT				
			Ex post	Ex ante			
				Case 1	Case 2	Case 3	Case 4
			n	n	n	n	n
PREFERENCES	**Personal**	User Payer Assessor	1	1	[*empty*]	[*empty*]	0 or N
	Non-use (N > 1)	Payer Assessor	n	n	pN	B(N,p)	0 or N
	Proxy (N > 1)	Assessor	n	n	pN	B(N,p)	0 or N
	Social	Member of payer group Assessor	n	n	pN	B(N,p)	0 or N
	Socially inclusive personal	Member of user and payer group Assessor	n	n	pN	B(N,p)	0 or N

Notes
N: the population of (potential) users; p: probability of illness; n: number of people ill ex post; N=n=1 for the personal preference
Ex ante, case 1: exactly n known patients will become ill
Ex ante, case 2: exactly n unknown patients will become ill
Ex ante, case 3: each of N individuals will become ill with independent probability p
Ex ante, case 4: all of N individuals will become ill with probability p
[*empty*] indicates that the cell is an empty set

Appendix

This Appendix introduces 22 stylised preference elicitation scenarios from 11 of the 23 possible perspectives outlined in the paper. These scenarios are not intended as templates for preference elicitation questions to be used in an actual survey. They are illustrations that convey the differences in the user, payer, assessor and timing between the different perspectives from which preferences can be elicited. Each stylised scenario will specify the following components:

- the timing of the illness and the nature of its risk,
- the patient, or the user of the treatment,
- the payer for the treatment, and
- the assessor of the value of treatment.

In the below, we will first set the context to ex post, and examine the five preferences (personal, non-use, proxy, social, and socially inclusive personal (SIP)), using examples in monetary valuation (contingent valuation: CV) and non-monetary health state valuation (time trade off; TTO). Our examples are chosen to illustrate the salient differences between the perspectives. We have chosen to illustrate these with CV and TTO tasks for simplicity. The perspectives framework would be applicable to any preference elicitation task. For instance, a discrete choice experiment (DCE) monetary valuation task would describe the good being valued as a bundle of attributes of which one is cost, but should still define the timing of illness, who uses the good, who pays for the good, and the respondents role as assessor of the good. Similarly, the TTO tasks can be reframed as standard gamble (SG) tasks if respondents trade off risk of death rather than years of life in full health, or a DCE_{TTO} task if the health is described as a multi-attribute bundle and respondents are asked to make trade-offs between two bundles of multi-attribute health and duration.

Then we move on to examine the ex ante context, where for brevity we focus on only two personal and four social preferences using CV scenarios. The points made in the ex ante context also

apply to the other preferences (non-use, proxy and SIP) and to the use of other elicitation formats such as TTO, SG and DCE.

It should be noted that the scenarios do not cover all the practical features of an actual scenario that would be included in a well-designed preference elicitation survey. For example, they do not refer to payment vehicles (e.g. out of pocket or insurance premium in CV and DCE monetary valuations; or time in TTO or risk in SG health state valuations), the routing and ordering (double bounded dichotomous choice or bidding game in CV; ping pong or titration in TTO or SG), framing effects (including subjective vs objective probabilities), the difference between risk and uncertainty, or other sources of bias. These other issues have already received extensive attention in health economics, in particular in the CV literature (Smith, 2003; Hackl and Pruckner, 2005; McNamee et al, 2010; Luchini and Watson, 2013; Ternent and Tsuchiya, 2013).

Each scenario is accompanied by a formal presentation of what the answer represents. The specifications of the utility and social welfare functions are left as open as possible: the actual functional forms are beyond the remit of this paper. The 22 scenarios are summarised in two tables: Table A1 presents 15 ex post CV and TTO scenarios; and Table A2 presents seven ex ante CV scenarios.

1. The ex post personal, social, and socially inclusive personal preferences

1.1. The ex post personal perspective

The welfare effect of a change in health can be measured using compensating surplus (Freeman, 1993). This builds on the concept of compensating variation, but does not involve changes in relative price and therefore is applicable to non-market goods like health. (Similarly, equivalent surplus corresponds to equivalent variation.) A CV study can elicit the change in income that cancels out the welfare effect of improved health from an ex post personal perspective – viz. compensating surplus.

Here is the example to illustrate the essence of the ex post personal perspective CV question with the respondents roles in square brackets:

(1) "Imagine you and only you currently have condition *X*: what is the maximum amount of money that you are willing to pay for a complete cure and be no worse off than in the current situation?" [ex post personal CV: user = you; payer = you; assessor = you]

The objective of the CV scenario in (1) is to identify the level of $-\Delta y_i$ that, given Δh_i and holding everything else constant, equalises the utility of two prospects so that:

$$u_i^i(y_i,h_i^X) = u_i^i(y_i-\Delta y_i,h_i^X+\Delta h_i),$$

where u_i represents the utility function of individual i; the superscript i indicates that it is as assessed by i; y_i represents income of individual i; h_i^X represents health of individual i in condition *X*; $h_i^X+\Delta h_i$ is assumed to represent recovery to full health; and utility is an increasing function of income and of health.

Scenario (1) distinguishes the three respondent roles: *user* as indicated by the subscript to h; the *payer* as indicated by the subscript to y; and *assessor* as indicated by the superscript to u. In scenario (1) the respondent i has all three roles. In any scenario, the respondent is always the *assessor* but need not be the *user* or *payer*.

An ex post personal TTO scenario that corresponds to (1) can be represented as:

(2) "Imagine you and only you currently have condition *X*: what is the maximum number of years of life in full health that you are willing to give up for a complete cure and be no worse off than in the current situation?" [ex post personal TTO: user = you; payer = you; assessor = you]

Health state valuations typically use "health state *X*" and specify a duration separately. However, we use "condition *X*" of no specified duration for comparability with CV. When translating a CV task into a TTO task, we do not follow all the TTO conventions for two pragmatic reasons: if health state *X* is

specified for 10 years (for example), then the alternative cannot be a "complete cure" as it is in the CV scenarios (a complete cure should not only achieve full health but also full life expectancy given current age); and we do not specify duration at any level because later example scenarios become contrived (e.g. when user ≠ payer).

Using the same formula above, this time, y represents years of life; and h represents health related quality of life. The objective of the TTO scenario is to identify the size of $-\Delta y_i$ that equalises the utility of two prospects captured by the formula, given Δh_i and holding everything else (including income) constant.

The wording of scenarios (1) and (2) does not exactly match the formula. The formula neutrally equates two outcomes, one with relatively high y and low h, and another with relatively low y and high h, without indicating how these outcomes occur. The verbal scenarios, on the other hand, indicate that "you" are invited to give up something of value ($-\Delta y_i$) *in exchange for* a complete cure ($+\Delta h_i$). In order to make the hypothetical scenarios mimic an actual market transaction, CV studies tend to favour such "exchange-based" wording. Arguably exchange-based wording, especially in health state valuation studies, may be susceptible to bias because it may invoke loss aversion or regret minimisation. With this caveat, we will continue to use exchange-based wording in our stylised scenarios, because it better facilitates the distinction between the user, the payer and the assessor roles than more neutral wording.

If the respondent is not the *user*, but remains the *payer* and *assessor* we have:

(3) "Imagine a group of *n* people (not including you) who currently have condition *X* (which you will never get): what is the maximum amount of money that you are willing to pay for a complete cure for those who have *X* and be no worse off than in the current situation?" [ex post personal non-use CV: user ≠ you; payer = you; assessor = you]

$$u_i^i(y_i, h_j^X) = u_i^i(y_i - \Delta y_i, h_j^X + \Delta h_j),\ i \neq j$$

The *user* (*j*) may be one person, or more. Everything else (such as *i*'s health or *j*'s income) is assumed to stay constant. Scenario (3) has similarities with the elicitation of "non-use values". Non-use values concern goods, for example, in a remote location that the respondent does not benefit from the use of directly. The valuation of non-use values separates the *user* and *assessor* roles; but not the *payer* and *assessor* roles. When the objective of the exercise is to estimate a non-use value in the form of individual compensating (or equivalent) surplus, then it is necessary that the *payer* role remains with the *assessor* role as in scenario (3). The term non-use value is hardly used in health economics, but such a scenario would elicit "caring externalities". This perspective is useful when valuing public preferences for prevention or treatment of illnesses that the at least some of the population will never get. For example, population valuation of a prostate cancer screening programme, or adult's valuations of childhood illnesses.

A TTO equivalent to (3) would look like this:

(4) "Imagine a group of *n* people (not including you) who currently have condition *X* (which you will never get): what is the maximum number of years of life in full health that *you* are willing to give up for a complete cure and be no worse off than in the current situation?" [ex post personal non-use TTO: user ≠ you; payer = you; assessor = you; same formula as scenario (3)]

This may appear unusual and contrived, because the nature of the payment numeraire (years of own life) requires the respondent's life to be shortened in exchange for a complete cure for a stranger. (However, people sacrifice their own health in order to improve the health of others, e.g. live organ donors, so a SG may feel less unusual.) They key here is the contrast in transferability of money and health.

Scenario (3) suggests that a social preference requires further separation of the *payer* role from the *assessor* role. But even that is not sufficient to elicit a social perspective. The below scenarios separate the *payer* and *assessor* roles but keep the *user* and *payer* roles together:

(5) "Imagine a group of *n* people (not including you) who currently have condition *X* (which you will never get): what is the maximum amount of money that you think they are willing to pay for a complete cure for themselves and be no worse off than in the current situation?" [ex post personal proxy CV: user ≠ you; user = payer ≠you; assessor = you]

$u_j^i(y_j,h_j^X) = u_j^i(y_j-\Delta y_j,h_j^X+\Delta h_j)$

(6) "Imagine a group of *n* people (not including you) who currently have condition *X*: what is the maximum number of years of life in full health that you think they are willing to give up for a complete cure for themselves and be no worse off than in the current situation?" [ex post personal proxy TTO: user ≠ you; user = payer ≠ you; assessor = you; same formula as scenario (5)]

Here, the respondent as *assessor* is asked for their view (superscript i for u) on a factual matter: the other person's own personal preference or wellbeing (u_j). It is another perspective that is not included in Dolan et al (2003; the DOMR paper): this might be called proxy judgements, and it falls short of social preferences. A proxy preference is elicited in studies that ask health care professionals or carers to complete preference elicitation tasks about treatment on behalf of their patients. The example illustrates that to build a social preference, the *user* and *payer* roles need to be separated from the *assessor* and each other.

1.2. The ex post social perspective

A social preference is distinguished by the kind of assessor that respondents are asked to be. For example, a social perspective can be operationalised by asking respondents to imagine themselves being an officer authorised to make decisions on the population's behalf. A scenario for an ex post social perspective might look like this:

(7) "Imagine a group of *n* people (not including you) who currently have condition *X*: what do you think is the maximum amount of money that *society* can pay for their complete cure and be no worse off than in the current situation?" [ex post social CV: user ≠ you; payer ≠ you; user ⊂ payer; assessor = you as decision maker]

As in (3) to (6) the *user* is somebody else ($n \geq 1$), and separated from the *assessor*. The respondent assesses ("what do you think"), the party who is assessed to be no worse off is not the respondent in person (so it is not a personal preference) but society (of *N* individuals), who is the (immediate) *payer*. Since society is made up of (and funded by) individuals, the *users* are likely to be a subset of the *payers*. The social CV scenario identifies the size of the aggregate willingness to pay (WTP), $\Sigma_N \Delta y_j$, that equalises the social welfare of two prospects:

$$W^I[u_1(y_1,h_1^X), \ldots, u_n(y_n,h_n^X), u_{n+1}(y_{n+1},h_{n+1}^F), \ldots, u_N(y_N,h_N^F)] = W^I[u_1(y_1-\Delta y_1,h_1^X+\Delta h_1), \ldots, u_n(y_n-\Delta y_n,h_n^X+\Delta h_n), u_{n+1}(y_{n+1}-\Delta y_{n+1},h_{n+1}^F), \ldots, u_N(y_N-\Delta y_N,h_N^F)],$$

where $j = 1, \ldots, N$; $I \neq j$; $\partial W^I/\partial u_j > 0$; and $\partial^2 W^I/\partial u_j^2 \leq 0$.

W^I represents social welfare, as assessed by an impartial decision maker I, and defined as a function of the utility of individuals. The *assessor*, or superscript, of individual utility is deliberately left open. Welfarism defines social welfare as a function of individual utility as assessed by the individual themselves, u_j^j; while non-welfarism uses individual utility, or welfare, as assessed by the decision maker, u_j^I. The scenario is akin to a transfer to the ill within society in a social welfare programme (where the ill themselves may also contribute). Note that the above (even the welfarist version) is not an aggregation of individual valuations of condition *X* captured by (1), and does not assume that $u_j(y_j,h_j^X) = u_j(y_j-\Delta y_j,h_j^F)$ holds for each *j*. It does not assume that all individuals pay the same amount, either. Because of these caveats, it may be difficult for a respondent to conceptualise aggregate WTP ($\Sigma_N \Delta y_j$) as a measure of treating *n* cases of *X*. Studies that aim to elicit monetary social valuations should be aware that respondents may have difficulty with this type of task and carry out thorough pre-testing.

A TTO scenario may look like this:

(8) "Imagine a group of *n* people (not including you) who currently have condition *X*: what do you think is the maximum number of years of life in full health that *society as a whole* are willing to give up for a complete cure for this group and be no worse off than in the current situation?" [ex post social TTO: user ≠ you; payer ≠ you; user ⊂ payer; assessor = you as decision maker; same formula as scenario (7)]

The difficulty of conceptualising $\Sigma_N \Delta y_j$ may be even greater for TTO than CV, since the idea of a total number of years of life given up by society as a whole is unique, and may be confusing especially if the number of people in the payer group (*N*) is much larger than the number of people in the user group (*n*): e.g. suppose *N* = 52 million and *n* = 100; it may not be immediately obvious that, for example 1 minute multiplied by 52 million people roughly amounts to 1 year multiplied by 100 people. Similar to monetary valuations, researchers who plan to use a TTO task to elicit an ex post social perspective should be aware of the difficulty that the task may pose for respondents.

An alternative approach to eliciting an ex post social perspective in scenarios (7) and (8) might be to exclude the users from the pool of payers, and to match the number of people in the user group and the payer group (*m*). Thus, for CV:

(9) "Imagine a group of *n* people (not including you) who currently have condition *X*: what do you think is the maximum amount of money that another group with the *same number of people* (*m* = *n*) in full health can give up for a complete cure for the first group and society to be no worse off than in the current situation?" [ex post subgroup social CV: user ≠ you; payer ≠ you; user ≠ payer; assessor = you as decision maker]

And, for TTO:

(10)"Imagine a group of *n* people (not including you) who currently have condition *X*: what do you think is the maximum number of years of life in full health that another group with the

same number of people (*m* = *n*) can give up for a complete cure for the first group and society to be no worse off than in the current situation?" [ex post subgroup social TTO: user ≠ you; payer ≠ you; user ≠ payer; assessor = you as decision maker]

The objective here is to identify the size of $\Sigma_N \Delta y_j$ that equalises the social welfare of two prospects ($N > n + m$):

$$W^I[u_1(y_1,h_1^X), \ldots, u_n(y_n,h_n^X), u_{n+1}(y_{n+1},h_{n+1}^F), \ldots, u_N(y_N,h_N^F)] = W^I[u_1(y_1,h_1^X+\Delta h_1), \ldots, u_n(y_n,h_n^X+\Delta h_n), u_{n+1}(y_{n+1}-\Delta y_{n+1},h_{n+1}^F), \ldots, u_{n+m}(y_{n+m}-\Delta y_{n+m},h_{n+m}^F), u_{n+m+1}(y_{n+m+1},h_{n+m+1}^F), \ldots, u_N(y_N,h_N^F)]$$

As with scenario (7), the assessment by the respondents concerns W^I: i.e. whether *society* is no worse off.

1.3 Person trade off and budget pie applications

If the numeraire of scenario (10) is changed from the number of years of life to the number of lives then this will result in a variant of the person trade-off scenario (PTO; Patrick et al, 1973; Murray, Lopez, 1997):

(11)"Imagine a group of *n* people (not including you) who currently have condition *X*: what do you think is the maximum number of lives in full health (*m*) that another group of people can give up for a complete cure for the first group and society to be no worse off than in the current situation?" [ex post subgroup social PTO: user ≠ you; payer ≠ you; user ≠ payer; assessor = you as decision maker; same formula as scenarios (9) and (10)]

The PTO scenario identifies the size of the second group ($m \leq n$) that equalises the social welfare of two prospects in the formula immediately above, but where y_j-Δy_j now indicates being dead (notwithstanding h_j^F). Some variants of the PTO do not compare condition *X* against full health, but against another condition (Nord, 1992). This would generate the *relative* value of one condition

against another. An actual PTO will contrast treating one group versus the other and a PTO scenario that builds on the framing of the preceding scenarios (in terms of compensating surplus) might look like this:

(12)"Imagine a group of *n* people who currently have condition X_n: what do you think is the maximum size (*m*) that another group of people who acquire condition X_m can be if the first group is completely cured and society is no worse off than in the current situation?" [ex post subgroup social relative PTO: user ≠ you; payer ≠ you; user ≠ payer; assessor = you as decision maker]

The respondent is in neither group. The objective here is to find the number *m* that would equalise the social welfare of two prospects, given *n* and where $N \geq n + m$:

$$W^I[u_1(h_1^{Xn}), \ldots, u_n(h_n^{Xn}), u_{n+1}(h_{n+1}^{F}), \ldots, u_N(h_N^{F})] = W^I[u_1(h_1^{Xn}+\Delta h_1^{n}), \ldots, u_n(h_n^{Xn}+\Delta h_n^{n}),$$
$$u_{n+1}(h_{n+1}^{F}-\Delta h_{n+1}^{m}), \ldots, u_{n+m}(h_{n+m}^{F}-\Delta h_{n+m}^{m}), u_{n+m+1}(h_{n+m+1}^{F}), \ldots, u_N(h_N^{F})]$$

Here, $h_j^{Xn}+\Delta h_j^{n}$ equals h_j^{F}, and y_j is assumed to be constant throughout and therefore dropped. Note that these examples of PTO elicit compensating surplus, where the tasks equate a health state improvement for group *n* with a reduction in health state or life years for group *m*. These are different from typical PTO tasks in the literature that elicit equivalent surplus, by equating health state improvements for one group with health state improvements for another group of a different size with a different health condition, instead. However, the examples emphasise the role a respondent has to take in an elicitation task for it to elicit a social perspective.

When cost per person is assumed to be the same across the two groups, the scenario becomes similar to a "budget pie" task that asks respondents to allocate a finite health care budget across competing treatments, to elicit their relative values. A budget pie scenario is framed in terms of the proportion of resources allocated to one treatment over the other, and thus of the number of people to be treated from each group (*n* + *m* = constant). But a (somewhat contrived) budget allocation scenario that is framed to match the PTO formula above might look like this:

(13)"Imagine there are two groups of people of equal size who currently have conditions X_n and X_m respectively, which cost the same per patient to treat, and not enough resources to treat everybody: what do you think is the combination of the number of people from each group to treat that would make treating either group equally good for society?" [ex post subgroup social budget pie: user ≠ you; payer ≠ you; user ≠ payer; assessor = you as decision maker; same formula as scenario (12); $n + m$ = constant]

Where a budget pie task is framed as a choice between two competing health improvements to one group versus another group, then this would elicit an equivalent surplus. If the respondent, instead, perceives the task as one where a reduction in health improvement for one group is compensated by an increase in health improvement to the other group, then the task will elicit a compensating surplus.

The last two scenarios (12) and (13) illustrate that in social preference elicitation tasks that separate the user and the payer, the trade-off need not be across two different goods (viz. money vs health; or survival vs health related quality of life) and can be across the same good (health) of different people, which allows the comparison between the social value of a unit of health to one group relative to another.

1.4. The ex post socially inclusive personal perspective

The DOMR paper states that in a socially inclusive personal perspective, "an individual is asked to consider her own self-interest as well as the interests of others" (p.546). The example in Menzel (1999) explicitly instructs the respondent to consider "both your own self-interest and what you think is best collectively" (p.264). Here is an ex post scenario that adapts scenario (7):

(14) "Imagine *a group of n people including you* currently have condition *X*: what do you think is the maximum amount of money that *society* can pay for a complete cure and be no

worse off than in the current situation?" [ex post socially inclusive personal CV: users ∋ you; payers ⊃ users; assessor = you as an individual and as a decision maker]

Under the socially inclusive personal perspective, the *assessor* is one of the *users*, and the *users* are a subset of the *payers* as in (7). The DOMR framework assumes that preference elicited from a fully personal perspective (1) and fully social perspective (7) will differ and the response to (14) will lie between these two. So, it may be possible to represent scenario (14) by introducing a relative weight (α) to capture this balance between scenarios (1) and (7): $\alpha W^I[u_{1,\ldots,} u_N] + (1\text{-}\alpha)u_i^i$. But within a range from α = 0 (identical to u_i^i) to α = 1 (identical to W^I), there is no guidance on what value this relative weight should take. A serious problem with eliciting the socially inclusive personal perspective is that unless responses to (1) and (7) are also elicited from the same respondents, there will be no way of gauging the relative weight (α) that each respondent gives self-interest and interests of others in (14).

A non-monetary valuation scenario using a TTO task to elicit a socially inclusive personal perspective might be built from (14) and (8), and look like this:

(15)"Imagine *a group of n people including you* currently have condition *X*: what do you think is the maximum number of years of life in full health that *society as a whole* can give up for a complete cure for your group and be no worse off than in the current situation?" [ex post socially inclusive personal TTO: users ∋ you; payers ⊃ users; assessor = you as an individual and as a decision maker]

The points made for (14) apply to (15). The valuation in (15) using socially inclusive personal TTO should lie between the valuations in the personal TTO (2) and the social TTO (8).

The social perspective tasks that asked about two different subgroups of individuals such as scenarios (9) to (13) are not possible in an ex post socially inclusive personal perspective, because in order for the assessor to be able to contrast the benefits to the *user* and the costs to the *payer*

without bias, she needs to be a member of both the user group and the payer group. Scenarios (9) to (13) do not allow this because they separate the user group from the payer group.

2. The ex ante personal and social preferences

Let us now move on to the context dimension and examine the ex ante context under personal, and social preferences. For simplicity, all the scenarios in this section are for CV tasks, but it is possible to construct equivalent TTO tasks for these in the same way as we have done in section 1 above. The seven ex ante scenarios discussed in this section are summarised in Table A2. When a future prospect needs to be assessed, this can be done either before the event on the basis of expected outcomes (ex ante), or after the event with respect to the realised outcomes (ex post).

In the paper we distinguish four "cases". Each can be illustrated using an example involving N individuals (none of whom are currently ill), and expected patient numbers of $n = pN$. DOMR distinguishes the ex ante and the ex post with reference to "the relative point in time at which the preference is elicited" (p.546) *and* imposes risk. As we show below, a future event does not have to involve risk, therefore, we add case 1, a future, ex ante context with no risk:

> **Case 1**: n known individuals will become ill and the rest will remain healthy; this might be thought of as a set of n cards each with an individual's name on it – there will be n patients for certain who are known beforehand but not yet ill.

DOMR also introduces risk of illness in a population without reference to the independence of probability of illness across members of the population. Cases 2-4 illustrate three possible probability correlations where $p<1$:

> **Case 2**: randomly selected n people from N will become ill and the rest will remain healthy; here, there is an envelope containing N cards, where n of them are marked for illness, and each of the

N individuals takes a draw, with *no* replacement– ex post there will be exactly *n* patients, although it is not known ex ante which individuals it will be;

Case 3: each of the *N* individuals have an independent probably *p* of becoming ill or otherwise remaining healthy; each of the *N* individuals takes a draw from the above envelope, *with* replacement – ex ante the expected number of patients is *n*, while the number ex post will follow a binomial distribution *B*(*N*,*p*) with mean of *n*;

Case 4: with probability *p* all individuals will become ill; otherwise all individuals will remain healthy; just one draw is taken from the same envelope for the whole group – ex ante the expected number of patients is *n*, while ex post it will be either zero or *N*, and never actually *n*.

2.1. The ex ante personal perspective

Assuming individuals are selfish and are not affected by the health of others, a personal version of these four cases, from individual *i*'s perspective, reduces to:

Case Ia: individual *i* will not become ill – as far as *i* alone is concerned, there will be no illness;

Case Ib: individual *i* will become ill – as far as *i* alone is concerned, there will be one patient (*i*) for certain;

Case II: with probability *p* individual *i* becomes ill; otherwise *i* remains healthy – the expected number of patients is *p*, although ex post it will either be one or zero, and never actually *p*.

Case Ia is not of interest (it is known that the individual will not become ill so the willingness to pay will be zero). Case II is a special case of case 4 above, where N=1. There are no corresponding cases to cases 2 and 3 above, since ex post, the number of patients has to be whole numbers.

In case 1 (Ib) there is no uncertainty – so this would not be ex ante in the conventional sense. However, the DOMR paper distinguishes ex-ante and ex post contexts with respect to the timing of

events. To follow this, it is possible to define CV (and TTO) tasks in which preferences are elicited before the event, with no uncertainty. A scenario for case Ib might look like this:

(16)"Imagine you are about to develop condition *X with certainty*: what is the maximum amount of money that you can pay *now* to *ensure a complete cure* in the future when you become ill and be no worse off than the current situation (not paying and facing the condition)?" [ex ante case I personal CV: user = you; payer = you; assessor = you]

$u_i^i(y_i,h_i^F-\Delta h_i) = u_i^i(y_i-\Delta y_i,h_i^F-\Delta h_i+\Delta h_i)$

For simplicity, we assume zero time preference. For an ex ante scenario to be meaningfully distinct from the corresponding ex post scenario, it is necessary to assume that cure is available only if payment is made now. Although DOMR only uses curative examples. In this case, an ex ante context is more realistic and more likely to be used by researchers to value preventative interventions. Furthermore, scenarios that describe developing the condition and having it cured are cumbersome, and it is not obvious that respondents will assume $u_i^i(y_i,h_i^F-\Delta h_i+\Delta h_i) = u_i^i(y_i,h_i^F)$. An example of a scenario that values a preventative intervention is:

(17)"Imagine you will develop condition X *with certainty*: what is the maximum amount of money that you can pay now for *a complete prevention* and be no worse off than the current situation (not paying and facing the condition)?" [ex ante case I prevention personal CV: user = you; payer = you; assessor = you]

$u_i^i(y_i,h_i^F-\Delta h_i) = u_i^i(y_i-\Delta y_i,h_i^F)$

However, preventative and curative scenarios have different welfare economic interpretations. The objective of the preventative scenario (17) is to identify the size of the payment ($-\Delta y_i$) that equalises the utility of two future prospects shown, given the size of the potential health loss ($-\Delta h_i$) and keeping everything else constant. In this scenario, the user is not yet ill and the CV task elicits an equivalent surplus of avoiding the health loss ($-\Delta h_i$), a bad, which makes two mutually exclusive outcomes equivalent: to keep the money and experience the illness; *or* to pay for the

prevention and not experience the illness. This is in contrast to curative scenarios, where the user is or will become ill and the CV task elicits a compensating surplus for the health gain (Δh_i), a good, which makes the value of two things cancel out: the benefit of the cure *and* the cost of paying for it. Welfare economic theory predicts that the compensating surplus (variation) of a good and the equivalent surplus (variation) of a bad will agree[1].

Introducing risk concerning future health in a personal perspective leads to the case II ex ante personal preventative for which a CV scenario might look like this:

(18)"Imagine you will develop condition *X* with probability *p*: what is the maximum amount of money that you can pay now for *a complete prevention* and be no worse off than the current situation (not paying and facing the risk)?" [ex ante case II personal preventative CV: user = you; payer = you; assessor = you]

$$pu_i^i(y_i,h_i^F-\Delta h_i) + (1-p)u_i^i(y_i,h_i^F) = u_i^i(y_i-\Delta y_i,h_i^F)$$

The answer, or the size of Δy_i, in (18) will depend on: the value of Δh_i; risk aversion or the shape of the utility function (u_i); and the subjective interpretation of probability p. In other words, by contrasting (18) with (17), the effect of people's aversion to risk and perception of probabilities can be examined. But if the objective of the study is to value Δh_i alone, the ex ante preference elicited in the valuation task would be confounded by both risk aversion and probability perception.

2.2. The ex ante social perspective

Similarly to the personal perspective, it is possible to build CV (or TTO) social perspective scenarios set before the event but involving no uncertainty. These would represent case 1. If we consider

[1] In both cases, respondents' WTP is elicited. Either the WTP for the good or the WTP to avoid the bad. This is different from the literature that compares WTP and willingness to accept compensation (WTA), which compares the compensating and equivalent variation of either the same good or the same bad. For instance, by comparing WTP for the good, and WTA for not receiving the good.

curative scenarios then an ex ante social CV scenario is obtained by modifying the ex post social perspective CV (7), and might look like this:

(19)"Imagine a group of *n* already identified people will develop condition *X* with certainty: what do you think is the maximum amount of money that *society* can pay now for a complete cure for this group in the future when they become ill and be no worse off than in the current situation?" [ex ante case 1 social]

$W^I[u_1(y_1,h_1^F-\Delta h_1), \ldots, u_n(y_n,h_n^F-\Delta h_n), u_{n+1}(y_{n+1},h_{n+1}^F), \ldots, u_N(y_N,h_N^F)] = W^I[u_1(y_1-\Delta y_1,h_1^F-\Delta h_1+\Delta h_1), \ldots, u_n(y_n-\Delta y_n,h_n^F-\Delta h_n+\Delta h_n), u_{n+1}(y_{n+1}-\Delta y_{n+1},h_{n+1}^F), \ldots, u_N(y_N-\Delta y_N,h_N^F)]$

Since the scenario concerns *n* known individuals, the subscripts *j* here identify unique individuals. This violates the anonymity assumption of conventional social welfare functions (that what matters for social welfare is the set of individual utilities and not the identity of who has what level of utility).

Cases 2, 3, and 4, all have $n=pN$ expected patients. Preference elicitation tasks can be constructed for each of these cases. The distinctions between each of the cases is useful when the researchers are also interested in people's aversion to risk or inequality. Under case 2, there will be pN (=n) patients with certainty, although it is not known beforehand who these will be. So while there is uncertainty at the individual level, there is no uncertainty at the social level, and the valuation task becomes:

(20) "Imagine a proportion *p* of *N* people will develop condition *X*: what is the maximum amount of money that society can pay now to ensure a complete cure for this group in the future if they become ill and be no worse off than the current situation (not paying and facing the risk)?" [ex ante case 2 social]

$W^I[u_1(y_1,h_1^F-\Delta h_1), \ldots, u_n(y_n,h_n^F-\Delta h_n), u_{n+1}(y_{n+1},h_{n+1}^F), \ldots, u_N(y_N,h_N^F)] = W^I[u_1(y_1-\Delta y_1,h_1^F-\Delta h_1+\Delta h_1), \ldots, u_n(y_n-\Delta y_n,h_n^F-\Delta h_n+\Delta h_n), u_{n+1}(y_{n+1}-\Delta y_{n+1},h_{n+1}^F), \ldots, u_N(y_N-\Delta y_N,h_N^F)]$

Note that this formula is the same as the one for scenario (19), but while scenario (19) violates anonymity (because the identities of the individuals matter), scenario (20) does not (and therefore individual identity is ignored). Since anonymity means that the *j* subscripts in (20) do not represent specific individuals and at the social level individuals are interchangeable, scenario (20) has no uncertainty in terms of overall outcomes – there will be *n* ill people for certain. This scenario will allow the researchers to elicit aversion to inequality in outcomes, in the absence of risk at the society level.

Under case 3, the health outcome will follow a binomial distribution with a mean of *pN*. A valuation task in this case can be based on the follow scenario:

(21) "Imagine *N* people are susceptible to develop condition *X* each with independent probability *p*: what is the maximum amount of money that society can pay now for a complete cure for this group in the future if they become ill and be no worse off than the current situation (not paying and facing the risk)?" [ex ante case 3 social]

$$W^I[\, pu_1(y_1,h_1^F-\Delta h_1) + (1-p)u_1(y_1,h_1^F),\ \ldots,\ pu_N(y_N,h_N^F-\Delta h_N) + (1-p)u_N\,(y_N,h_N^F)\,] = W^I\,[pu_1(y_1-\Delta y_1,h_1^F-\Delta h_1+\Delta h_1) + (1-p)u_1(y_1-\Delta y_1,h_1^F),\ \ldots,\ pu_N(y_N-\Delta y_N,h_N^F-\Delta h_N+\Delta h_N) + (1-p)u_N(y_N-\Delta y_N,h_N^F)]$$

Here, expected social welfare is expressed as a function of expected utility of individuals. As with (7), this does not assume $pu_j(y_j,h_j^F-\Delta h_j) + (1-p)u_j(y_j,h_j^F) = pu_j(y_j-\Delta y_j,h_j^F-\Delta h_j+\Delta h_j) + (1-p)u_j(y_j-\Delta y_j,h_j^F)$ for each individual *j*, or that individuals pay the same amount. The response to such a scenario will depend on: the value of Δh_j; the shape of the social welfare function (W^I); and the respondent's subjective interpretation of probability *p*. The shape of the social welfare function can represent risk aversion, inequality aversion, or both. Since both kinds of aversion result in diminishing marginal social welfare in individual utility, the two cannot be distinguished from each other using a preference elicitation task of the format in scenario (21).

Under case 4, the expected number of patients is pN, but ex post, there will be either zero or N patients, and never pN (= n).

(22) "Imagine that with probability p everybody (N) will develop condition X; otherwise everybody will remain healthy: what is the maximum amount of money that everybody in this group can pay now for a complete cure for themselves in the future if they become ill and be no worse off than the current situation (not paying and facing the risk)?" [ex ante case 4 social]

$$pW^I[u_1(y_1,h_1^F-\Delta h_1), \ldots, u_N(y_N,h_N^F-\Delta h_N)] + (1-p)W^I[u_1(y_1,h_1^F), \ldots, u_N(y_N,h_N^F)] = pW^I[u_1(y_1-\Delta y_1,h_1^F-\Delta h_1+\Delta h_1), \ldots, u_N(y_N-\Delta y_N,h_N^F-\Delta h_N+\Delta h_N)] + (1-p)W^I[u_1(y_1-\Delta y_1,h_1^F), \ldots, u_N(y_N-\Delta y_N,h_N^F)]$$

This scenario can be used to elicit social-level aversion to risk, in the absence of (ex post) inequality across individuals. The distinction between elicitation tasks that take the form of (20), (21), and (22) is important. A task framed as in (21) means that risk aversion and inequality aversion are confounded. We argue that researchers eliciting ex ante social preferences should use tasks based on scenarios (20) or (22) and be aware that they elicit social preferences and either risk or inequality aversion.

Table A1: Summary of ex post preference scenarios

preference	user	payer	trade[b]	CV[c]	TTO	PTO	BP	
Personal	you	you	across different goods	(1)	(2)			$u_i^i(y_i,h_i^X) = u_i^i(y_i-\Delta y_i,\ h_i^X+\Delta h_i)$
Non-use	≠ you			(3)	(4)			$u_i^i(y_i,h_j^X) = u_i^i(y_i-\Delta y_i,\ h_j^X+\Delta h_j),\ i \neq j$
Proxy		user		(5)	(6)			$u_j^i(y_j,h_j^X) = u_j^i(y_j-\Delta y_j,\ h_j^X+\Delta h_j)$
Social	∌ you	society		(7)	(8)			$W^I[u_{1\ldots n}(y_j,h_j^X);\ u_{n+1\ldots N}(y_j,h_j^F)] = W^I[u_{1\ldots n}(y_j-\Delta y_j,h_j^X+\Delta h_j);\ u_{n+1\ldots N}(y_j-\Delta y_j,h_j^F)]$ [d]
		subgroup		(9)	(10)	(11)		$W^I[u_{1\ldots n}(y_j,h_j^X);\ u_{n+1\ldots N}(y_j,h_j^F)]$ $= W^I[u_{1\ldots n}(y_j,h_j^X+\Delta h_j);\ u_{n+1\ldots n+m}(y_j-\Delta y_j,h_j^F);\ u_{n+m+1\ldots N}(y_j,h_j^F)]$
			same			(12)	(13)	$W^I[u_{1\ldots n}(h_j^{Xn});\ u_{n+1\ldots N}(h_j^F)] = W^I[u_{1\ldots n}(h_j^F);\ u_{n+1\ldots n+m}(h_j^{Xm});\ u_{n+m+1\ldots N}(h_j^F)]$ [e]
SIP[a]	∋ you	society	different	(14)	(15)			$\alpha W^I[u_{1\ldots N}] + (1-\alpha)u_i^i$

a) SIP: Socially inclusive personal;

b) Trade: "across different goods" money and health (CV) or survival and HRQOL (TTO); "same" trading same good (across different people)

c) CV: Contingent valuation; TTO: Time trade off; PTO: Person trade off; BP: Budget pie

d) $W^I[u_{1\ldots n}(y_j,h_j^X);\ u_{n+1\ldots N}(y_j,h_j^F)]$ is a shorthand for $W^I[u_1(y_1,h_1^X),\ \ldots,\ u_n(y_n,h_n^X),\ u_{n+1}(y_{n+1},h_{n+1}^F),\ \ldots,\ u_N(y_N,h_N^F)]$

e) $m + n = \text{constant}$, for (13)

Table A2: Summary of ex ante CV scenarios[a]

preference	user	payer	cur/pre[b]	Ex post n	case	CV	
Personal	you	you	cur	1	I	(16)	$u_i^i(y_i,h_i^F-\Delta h_i) = u_i^i(y_i-\Delta y_i,h_i^F-\Delta h_i+\Delta h_i)$
			pre			(17)	$u_i^i(y_i,h_i^F-\Delta h_i) = u_i^i(y_i-\Delta y_i,h_i^F)$
				0 or 1	II	(18)	$pu_i^i(y_i,h_i^F-\Delta h_i) + (1-p)u_i^i(y_i,h_i^F) = u_i^i(y_i-\Delta y_i,h_i^F)$
Social	≠ you	society	cur	n	1	(19)	$W^I[u_{1\ldots n}(y_j,h_j^F-\Delta h_j); u_{n+1\ldots N}(y_j,h_j^F)] = W^I[u_{1\ldots n}(y_j-\Delta y_j, h_j^F-\Delta h_j+\Delta h_j); u_{n+1\ldots N}(y_j-\Delta y_j,h_j^F)]$ [c]
				$pN = n$	2	(20)	$W^I[u_{1\ldots n}(y_j,h_j^F-\Delta h_j); u_{n+1\ldots N}(y_j,h_j^F)] = W^I[u_{1\ldots n}(y_j-\Delta y_j, h_j^F-\Delta h_j+\Delta h_j); u_{n+1\ldots N}(y_j-\Delta y_j,h_j^F)]$ [d]
				$B(N,p) = n$ [e]	3	(21)	$W^I[pu_1(y_1,h_1^F-\Delta h_1) + (1-p)u_1(y_1,h_1^F), \ldots, pu_N(y_N,h_N^F-\Delta h_N) + (1-p)u_N(y_N,h_N^F)]$ $= W^I[u_{1\ldots n}(y_j-\Delta y_j, h_j^F-\Delta h_j+\Delta h_j); u_{n+1\ldots N}(y_j-\Delta y_j,h_j^F)]$ [4]
				0 or N	4	(22)	$pW^I[u_{1\ldots N}(y_j,h_j^F-\Delta h_j)] + (1-p)W^I[u_{1\ldots N}(y_j,h_j^F)]$ $= pW^I[u_{1\ldots N}(y_j-\Delta y_j, h_j^F-\Delta h_j+\Delta h_j)] + (1-p)W^I[u_{1\ldots N}(y_j-\Delta y_j,h_j^F)]$

a) See the text for ex ante personal TTO, social TTO, and SIP CV
b) cur/pre: curative or preventative; *N*: the population; *n*: actual number of patients = *pN*
c) non-anonymous: the *j* subscripts identify unique individuals
d) anonymous: the *j* subscripts represent interchangeable individuals
e) *B*(*N*,*p*): binomial distribution with *N* trials and probability *p*, with mean of *n*

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