Economic evaluation, value of life,
stated preference methodology and determinants of risks

To my family and friends

Örebro Studies in Economics 21

BJÖRN SUND

Economic evaluation, value of life, stated preference methodology and determinants of risks

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Abstract

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The first paper examines the value of a statistical life (VSL) for out-of-hospital cardiac arrest (OHCA) victims. We found VSL values to be higher for OHCA victims than for people who die in road traffic accidents and a lower-bound estimate of VSL for OHCA would be in the range of 20 to 30 million Swedish crowns (SEK).

The second paper concerns hypothetical bias in contingent valuation (CV) studies. We investigate the link between the determinants and empirical treatment of uncertainty through certainty calibration and find that the higher the confidence of the respondents the more we can trust that stated WTP is correlated to actual WTP.

The third paper investigates the performance of two communication aids (a flexible community analogy and an array of dots) in valuing mortality risk reductions for OHCA. The results do not support the prediction of expected utility theory, i.e. that WTP for a mortality risk reduction increases with the amount of risk reduction (weak scope sensitivity), for any of the communication aids.

The fourth paper presents a cost-benefit analysis to evaluate the effects of dual dispatch defibrillation by ambulance and fire services in the County of Stockholm. The intervention had positive economic effects, yielding a benefit-cost ratio of 36, a cost per quality-adjusted life-year (QALY) of € 13 000 and the cost per saved life was € 60 000.

The fifth paper explores how different response times from OHCA to defibrillation affect patients' survival rates by using geographic information systems (GIS). The model predicted a baseline survival rate of 3.9% and reducing the ambulance response time by 1 minute increased survival to 4.6%.

The sixth paper analyzes demographic determinants of incident experience and risk perception, and the relationship between the two, for eight different risk domains. Males and highly educated respondents perceive their risks lower than what is expected compared to actual incident experience.

Keywords: Cost-benefit analysis, value of a statistical life, contingent valuation, cardiac arrest, defibrillation, calibration, sensitivity to scope, risk communication, response times, incident experience, risk perception.

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Göteborg, December 2010
Björn Sund

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1. Introduction

Trying to match health and economic issues inevitably leads to many ethical questions. How can we let people die when we know that additional resources would save lives? The answer is that there are many things other than health that are important to us. We want to travel, eat, live well, buy clothes, and go to the movies and so on. The fact that we engage ourselves in many risky activities such as driving, mountain climbing or taking a shortcut over a road in spite of using an existing pedestrian tunnel suggests that we focus on more than health.

The purpose of economic evaluation is to help social decision making, i.e. to allocate society's resources efficiently. In particular, a cost-benefit analysis (CBA) tries to consider all costs and benefits of a policy to society as a whole. The basic decision rule is to adopt the project if the benefits exceed the costs. CBA therefore provide a framework for measuring efficiency and allows for direct comparisons among alternative policies. The theoretical base for the measurements of benefits and costs in CBA is welfare economics, which seeks to measure the change in utility from a policy. But how do we measure individual utility?

We all strive to achieve a high level of wellbeing in our lives. 'Wellbeing' does not have the same meaning to different individuals; hence it is a preference-based concept. Since preferences are revealed in market places, willingness to pay (WTP) for a specific good or service is a measure of wellbeing. Alternatively, the minimum amount a respondent would be willing to accept (WTA) in compensation for a deterioration could be used. Whether to use WTP or WTA depends upon the relevant property right to the good. WTP and WTA are measures of social costs or social benefits and therefore constitute important ingredients of CBA.

One implication of fully assessing the economic value of a policy is that non-market goods, whenever they occur, have to be taken into account. Non-market goods have no market, i.e. no explicit exchange between buyers and sellers take place, or the market may be limited or incomplete. Examples of non-market goods may be: cultural sites, air or water quality, noise, risk reduction policies and certain segments of healthcare. Many non-market goods have economic value in the sense that they contribute to individuals overall utility level (wellbeing).

There are several techniques that have been developed to assess the value or non-market goods. Generally, the impacts can be valued from observed behaviour (revealed preferences) or through surveys (stated preferences). Both approaches have their advantages and weaknesses, but have the potential to deliver an indication of the value for non-market goods. Ignoring

or implicitly assigning a value for these goods may result in considerable differences in societal investments, which questions the rationality behind the implemented policies (Ramsberg & Sjöberg, 1997; Goebbels et al., 2008).

A further aspect that the decision-maker shall take into account is the allocation of resources within the society. It raises ethical questions about e.g. whether we should pursue to improve the health of those who have the worst health status, or whether resources should be used where they are most effective (largest health status improvement). Valuation of individual freedom should also be made, e.g. in cases such as introduction of compulsory cycle helmets or bans on smoking in public places. Such values are not essential for an analyst to consider explicitly. However, the effects should be clarified as far as possible to provide a good basis for decision-making. Economic evaluation should be regarded as a normative tool and other inputs should be allowed to influence the decision process.

2. Economic evaluation

The purpose of economic evaluation is to help social decision making and maximize the well-being of society by allocating resources in a more efficient way. In health economics the policy evaluated may be e.g. a new medical treatment or a public health intervention. As we will see below, different analyses can be used to assess benefits and costs to a policy. Mainly, two frameworks/philosophies are at hand when performing an economic evaluation (Gyrd-Hansen, 2005): (1) the 'welfarist' framework and (2) the 'extra-welfarist' framework. Which should be chosen depends on which type of comparison that is wanted by the decision-maker and the possibilities to measure the outcome. Table 2.1 compares these two frameworks with respect to certain characteristics.

Table 2.1. Economic evaluation frameworks

	Welfarist	**Extra-welfarist**
Focus	Output of medical care should be judged against all other goods	Output of medical care should be judged against all other types of treatment
Function to maximize	U(x,h(m)); s.t.: x+pm=I	h(m); s.t. [h(m)-h(o)]/p>C
Individual heterogeneity	Different individuals value the same health state differently	Assume that everyone values health states similarly
Analysis	Cost-benefit analysis (CBA)	Cost-effectiveness analysis (CEA)
Advantage	Theoretically superior	Easier to implement in practice

Source: Healthcare-Economist.com, February 18, 2008 (accessed November 9, 2010).

First, the focuses of the frameworks are utility ('welfarist') and health status ('extra-welfarist'). The 'welfarist' maximizes individual utilities subject to a budget constraint (I), while the 'extra-welfarist' maximizes health by choosing policies that are below a certain threshold (C). Second, the differences in individual heterogeneity implies that treating a person who copes well with a certain disease is not as efficient as treating a person who copes poorly according to the 'welfarist' framework (individual preferences matter). For the 'extra-welfarist' the outcome measure is health itself, i.e. the treatment of the two persons would produce equal values. Third, Table

2.1 highlights the methods at hand, cost-benefit and cost-effectiveness analysis, and summarizes the major advantages of the philosophies.

Below, we deepen the discussion of the economic evaluation analyses. Cost-of-illness analysis complements the overview and a special case of cost-effectiveness analysis (cost-utility) is presented.

2.1 Cost-of-illness

The cost-of-illness (COI) analysis estimates the economic burden of specific diseases or accidents, e.g. traffic accidents, smoking, cancer or stroke. It delivers a monetary sum that describes the scope of a 'problem'. Examples of COI results in Sweden are (Olofsson, 2008): SEK 5.7 billion (diabetes), SEK 20.3 billion (alcohol consumption), SEK 37.0 billion (accidents) and SEK 270.0 billion (diseases). The use of COI has been questioned, since it does not provide any information on the marginal effectiveness of different interventions and it may mislead resources to diseases or accidents that are costly (Shiell et al., 1987; Byford et al., 2000). Arguments in favour of COI are that it is informative, puts costs of diseases into perspective, provides an economic framework for e.g. cost-effectiveness analysis and gives an insight into cost trends if performed at different points in time (Hodgson, 1994; Koopmanschap, 1998). Despite its inability to say anything on how to prioritize between interventions, the interest in COI analysis has stimulated development of methods to calculate direct and indirect costs of illnesses as well as production of relevant data (Johannesson & Jönsson, 1991).

2.2 Cost-effectiveness

The development after cost-of-illness led forward to another evaluation method; cost-effectiveness analysis (CEA). In CEA, costs are measured in monetary units and effects in physical units. The physical units in health economics would typically be the number of survivors or the number of life-years gained. Cost-effectiveness requires a fixed budget to assess which policies to carry out and is best suited for comparing policies with the same one-dimensional effect, e.g. maximize the number of life-years gained within a given budget ('extra-welfarism'). It is popular in health economics, mainly since it avoids measuring effects in monetary terms explicitly (Johannesson & Jönsson, 1991). The ratio of cost/effect is straightforward to compare.

However, it is not possible to determine whether a policy is desirable from society's perspective. CEA often uses a threshold to determine the efficiency and therefore maximizes the decision-makers preferences. For

Sweden, a cost-effectiveness threshold value of € 65 000 is often used (National Board of Health and Welfare, 2007), indicating an implicit value of health in monetary terms. Also, the one-dimensional effect limitation causes problems. Consider a policy A that saves X lives and policy B that reduces noise from road traffic to a number of individuals by Y decibel. How do we weigh these policies versus one another? Without a common currency (e.g. money) this is impossible. Other problem areas to assess are which costs to include and the discounting of effects (Johannesson & Jönsson, 1991).

2.3 Cost-utility

One special case of cost-effectiveness analysis is a cost-utility analysis (CUA), where life-years gained are adjusted for quality of life. Thus, CUA combines both qualitative effects (quality of life) and quantitative effects (life-years gained). A weight of zero reflects a health status equal to being dead and one reflects full health, i.e. every life-year is assigned a weight between 0 and 1. The breakthrough of CUA begun in the 1960s (Klarman et al., 1968) and it is most useful for policies that affect both mortality and morbidity. Like CEA, CUA requires a fixed budget to maximize the quality-adjusted life-years (QALYs) gained, unless one unique willingness to pay per QALY can be established (Gyrd-Hansen, 2005).

The measurement of the quality weights is debated. It is questioned whether QALYs should be based on decision-maker preferences, i.e. 'extra-welfarism', or on individual preferences, i.e. 'welfarism' (Johannesson et al., 1996). The techniques used to measure the weights: rating scales (RS), standard gamble (SG), time-trade-off (TTO) and person trade-off (PTO) produces considerable differences in results and therefore questions the validity (Nord, 1992). Also, the dimensions of quality of life measurement (physical function, health perceptions, social function, pain and energy) are collapsed into scores between 0-1, which ranks are not certain to reflect individual preferences in the composite form (Johannesson et al., 1996).

2.4 Cost benefit

Cost-benefit analysis (CBA) implies that both benefits and costs are valued in a common currency (money) as far as possible. Benefits are measured as the maximum willingness to pay for an intervention and costs are measured as opportunity costs (best alternative use). CBA is based on whether the output contributes to overall welfare, i.e. the sum of individual utilities ('welfarism'). If a unique WTP per QALY can be established, the CUA evaluation is in practice transformed to CBA (Gyrd-Hansen, 2005). The

output, measured in monetary terms, makes it easier to decide whether a policy should be carried out or not by simply comparing if the benefits are greater than the costs. A positive B/C-quota means that society's welfare is increased and the policy should, in principle, be implied. Also, CBA is able to compare multi-dimensional benefits.

The major steps in CBA involves (Boardman et al., 2001): (1) specify the set of alternative projects, (2) decide whose benefits and costs count (standing), (3) catalogue the impacts and select measurement indicators (units), (4) predict the impacts quantitatively over the life of the project, (5) monetize (attach dollar values to) all impacts, (6) discount benefits and costs to obtain present values, (7) compute the net present value (NPV) of each alternative, (8) perform sensitivity analysis, and (9) make a recommendation based on the NPV and sensitivity analysis. The formal expression for the NPV is:

$$NPV = \sum_{t=1}^{T} \frac{B_t - C_t}{(1+r)^t}$$

where:
NPV= net present value of the project
B_t= social benefits of the project at time t
C_t= social costs of the project at time t
r = social discount rate
T = the number of time periods that defines the life of the project

Valuation of all goods in monetary terms is sometimes difficult and that is why many studies are content with a CEA/CUA. They are simply easier to implement. Performing a CBA may be constrained by the following reasons (Boardman et al., 2001): (1) inability or unwillingness to monetize the most important effects, (2) the effectiveness measure captures most of the effects, i.e. monetizing all effects may not be reasonable, and (3) the effect of intermediate goods are not clear. Goods where markets don't exist are especially difficult and in the health area reduced mortality and morbidity are controversial benefits to value in monetary terms. Below, the methods to address this problem are discussed.

3. Valuation of statistical lives

3.1 Definition

The value of a statistical life (VSL) is a measure of the trade-off between income and mortality risk reductions. In essence, this means that VSL is the value that society deems economically efficient to spend on avoiding one (unidentified) premature death. Especially in transport safety, environmental and health economics, VSL is often a key input in policy evaluations when performing cost-benefit analysis (CBA). A measure of VSL is essential in optimising policy in fields where weighting the saving of human lives against other effects and costs frequently occur.

Estimating VSL means that we are examining the rate at which people are prepared to trade off income for a reduction in the risk of dying. In a standard theoretical model of one individual's baseline mortality risk (p) [$0 \leq p \leq 1$], where $u_a(y)$ and $u_d(y)$ are the individual's utility as a function of income (y) conditional on staying alive (a) and dying (d), the expected utility is equal to (Jones-Lee, 1974; Alberini, 2005):

$$EU[p,y] = (1-p)u_a(y) + pu_d(y). \quad (1)$$

The model is simplified to only consider a marginal change in the probability of one individual's own death and also within a specified time period. Assuming that utility of income is zero when the individual is dead ($u_d=0$), simplifies the expression to $(1\text{-}p)u_a(y)$. Then the trade-off between income and risk will be (Arrow et al., 1993; Carson & Groves, 2007):

$$VSL = \frac{dy}{dp} = \frac{u_a(y)}{(1-p)u'_a(y)}. \quad (2)$$

In practice, VSL is not estimated by using the derivative, but instead by estimating WTP for a specified risk reduction (Δp). Then, VSL is estimated as:

$$VSL = \frac{WTP}{\Delta p} \quad (3)$$

The two approaches that are used to estimate WTP for reduced mortality risks are: (1) revealed preferences and (2) stated preferences. Also, the human-capital approach has been applied, but it was mainly important a few decades ago. Below, the approaches are presented in more detail, but first an ethical discussion of valuation of life.

3.2 Ethical discussion

Establishing a monetary value of a human life is a sensitive issue in several aspects. Religious, moral and ethical beliefs are challenged and the allocations of scarce economic resources are not always consistent with these beliefs. Objections against valuing human life in terms of money are: (1) it is unethical and (2) assessing a finite value of life is wrong (Zweifel et al., 2009). Would such a value lead to that we would ignore expenses that reduce the risk of dying for individuals whose value do not cover their cost of living? What happens for the old, the poor, the disabled, the sick or those with any other personal attribute that may decrease their 'productivity'? Heterogeneous value of life is an extremely sensitive issue and in the US there have been legislation proposals against reduction of VSL values based on individual heterogeneity (Viscusi, 2010).

Actually, we must remember that the trade-off is not normally between life against money, but rather between remaining life expectancy and money. A policy that 'saves' lives do not prolong these lives forever; it merely increases remaining life expectancy, which may be easier to accept morally. Also, there is a relevant difference between active intervention (killing a person) and letting nature run its cause (refrain from policies that would save additional lives). In society, we constantly observe behaviour that implies that individuals' lives have a finite value to them. E.g. smoking, skydiving, driving a car or riding a bicycle without helmet suggest that avoiding small risks is not infinitely valuable.

In many public decisions, individuals' health or even the risk of dying are affected. For most of these decisions it is 'statistical' lives and not 'identified' lives that are considered. A large group of individuals is affected by e.g. speed cameras on roads, fire detectors in public buildings, quality controls on food or lower emissions from factories. As long as it is not known who will be affected, we use the anonymous term 'statistical' life. Let's say that the risk of dying decreased from 0.00010 to 0.00009 per year for a group of 100 000 individuals as a result of a policy, we would save one 'statistical' life per year. If the individuals were identified, e.g. like the 33 buried miners in the San José mine in Chile 2010, the policy makers are expected to do everything possible to save their lives. We would not expect

the same amount of money spent per miner to prevent future accidents, i.e. VSL is only useful in ex-ante evaluations of small changes in mortality risks.

Assigning an implicit or explicit finite value to life implies that policy makers are able to weigh risks against other types of goods. As human beings, we do not only want to consume safety but also be able to live in a good home, travel, eat good food and visit cinemas among other things. This is why we do not spend all of our resources on maximized safety. A policy maker that neglects valuing lives may prioritize projects where the efficiency is low. The consistency of policies is allowed to vary and the goal of greatest social benefit per monetary unit spent on reducing mortality risk is not optimized. Also, taking the preferences of the citizens into account is a democratic principle and accordingly a valuation of statistical life based on individual preferences is consistent with generally accepted ethic norms (Mattsson, 2006).

3.3 The human-capital approach

Since the development of human capital theory in the 1960s, this approach has been used to value a statistical life. The definition of the value of life in this setting is: "…the discounted sum of the individual's future (marginal) contributions to the social product, which corresponds to future labor income, provided the wage is equal to the value marginal product." (Zweifel et al., 2009). Either the gross human capital (the discounted sum of the individual's future, foregone, earnings) or the net human capital (gross human capital minus the individual's future consumption) can be estimated. It is apparently a direct and easy to use method that to a large extent has been applied in cost-of-illness studies (Johannesson & Jönsson, 1991).

Despite its relative simplicity to operationalize, there are severe economic and ethical disadvantages that reduce its applicability. There is no base in economic welfare theory (individual valuation) and it discriminates pensioners and others outside the labour force as their value of life is zero (or even negative). The approach is sometimes referred to as adapting a slave-owners perspective. Also, it ignores the pleasure of living, which makes it a poor measure of the value of life. Therefore, the lack of validity of the human-capital approach leads us to the willingness-to-pay approach.

3.4 The willingness-to-pay approach

3.4.1 Revealed preferences

The revealed preference (RP) approach uses market data on observed behaviour among individuals to estimate implicit WTP for changes in mortality risks. The strength in using RP techniques is that if a person actually pays €X to buy a specific good, we know with certainty that this persons WTP for the good is at least €X (Bateman et al., 2002). Unfortunately, markets fail to provide relevant WTP data in many cases. This is the case for many public goods, e.g. health or environment. Instead, RP techniques use information from proxy private goods markets, which is not as reliable.

Examples of proxy markets where RP techniques have been used are WTP for national parks by measuring the expenses paid to visit them; WTP for avoiding noise by comparing identical houses affected by different levels of noise; and WTP for safety purchases such as air-bags, smoke-detectors or precautionary behaviour to wear seat-belts or bicycle helmets (Blomqvist, 2004; Svensson, 2009a). Blomqvist (2004) found that the 'best' VSL estimates from a number of consumer behaviour studies are close to $\$_{2000}4$ million.

However, the most explored market for RP studies is the labour market, where wage premiums are offered to workers to accept more risky jobs. Viscusi & Aldy (2003) reviews a large number of studies of mortality risk premiums and shows that VSL is typically in the range of $\$_{2000}4$ million to $\$_{2000}9$ million using U.S. labour market data. They also find that these values are similar to values generated by product market and housing market studies. From another meta-analysis (Miller, 2000) it seems that the VSL values based on averting behaviour in consumption are lower than VSL values based on labour wage-risk trade-offs.

RP studies require both fitted data and a strategy to isolate the risk-money trade-off. Besides the safety level, there are a number of factors that affect wages. Statistical analyses have to control for both differences in worker productivity and different quality components of a job (Viscusi & Aldy, 2003). The hedonic wage methodology is an appropriate approach, but it is typically not able to capture all the benefits of a specific public good (Bateman et al., 2002). Also, RP studies are restricted to market contexts and there are many situations where it is of interest to simulate market behaviour to value a good.

3.4.2 Stated preferences

Instead of using market data, the stated preference (SP) technique uses surveys to estimate VSL values. It resembles a market-survey and it is able to examine WTP for hypothetical changes in mortality risks since it simulates market behaviour (Bateman et al., 2002). Also, SP tries to capture both direct use and non-use (passive use) values. Direct use value arises when an individual physically experience a commodity, while non-use arises when utility occur even if the commodity is not in direct contact of it (Carson et al., 2001). One classic example of passive use value is natural wonders, which many people value simply for their existence (Krutilla, 1967).

Contingent valuation (CV) and choice experiments (CE) are the two types of SP approaches that have been used. They are very similar in structure, but they differ in the way the choice is offered to the respondent. For CV, the choice is a bundle of different attributes where the price level is varied. For CE, several attributes are varied (including price) which makes it possible to retrieve WTP for each attribute as well as WTP for the bundle of attributes (Krupnick, 2007). Figure 3.1 shows an example of a discrete CE. The attributes are the number of deaths, life years lost and the price level. Respondents choose between the current situation with a specific 'health level' and a new policy with a better 'health level' but with an accompanying cost. Normally, the choice set is repeated for the respondents and the attribute levels are varied between the sets.

CE originates from marketing and has been popular in transport and environmental economics for recent years. Compared to CV, it is more flexible in that it sorts out the effects on WTP of different attributes, e.g. a better opportunity to analyse if older respondents have a lower WTP for mortality risk reductions than younger respondents (Krupnick, 2007). At the same time, the choice becomes more complex. This is particularly problematic in the case of valuing low-level changes in health risks, where the problem of scope insensitivity and embedding are often found to be severe (see Section 4.2.2).

In the beginning of its 'history', CE brought some hope to practitioners that the biases of the CV technique should be solved. However, this hope has not been realised and CE and CV may be regarded as complements. The choice of SP approach depends more on what research questions we are willing to study. In Section 4, we continue with a deeper discussion of CV and some of the most debated biases, which also applies to CE.

VSL estimates from SP studies are generally higher than VSL estimates from studies of averting behaviour in consumption and wage-risk tradeoffs, i.e. RP studies (Miller, 2000; de Blaeij et al., 2003). One explanation

may be hypothetical bias in the case of SP studies (see Section 4.2.1 for a deeper discussion). The magnitude of VSL estimates is vastly different and in a meta-analysis of road safety VSL ranges from $\$_{1997}$ 200 000 to $\$_{1997}$ 30 million (de Blaeij et al., 2003). Also, the meta-analysis finds that WTP for a risk reduction is higher for private than for public goods. Much of the studies of VSL are about road safety, but the type of death is likely to affect the stated WTP as well (Zweifel, 2009).

Figure 3.1. Example of a discrete choice experiment

This will happen in your community in the coming 10 years	**Current situation**	**New policy**
Deaths per 10 000 people	110	107 (3 persons are saved)
Total amount of years lost	1100	1000 (33,3 saved years per saved life)
Your total cost for 10 years	Current taxation	+2000 (+200 SEK per year)
I choose (put a cross in a square):	□ Current situation	□ New policy

Source: Nerhagen & Li (2010)

4. Contingent valuation

The idea of the contingent valuation (CV) technique is to measure people's willingness to pay (WTP) or willingness to accept (WTA) by creating a hypothetical market survey situation. The respondents are expressing their WTP/WTA through a direct question, but no actual payment is made. CV has potential to measure non-use values and also it is able to evaluate changes in quantity or quality of goods or services that do not exist, i.e. it is not restricted to market contexts.

Davies (1963) was the first to use the CV method in an attempt to value a recreational area. After that, CV continued to be more or less an academic issue for two decades. Then, in 1989, the Exxon Valdez oil spill led to a controversy of whether CV provides reliable estimates for non-use values of Alaskan natural resources. The damage was settled out of court, but the role of CV was still debated. Hausman (1993) published a number of critical studies. In the same year, Arrow et al. (1993) reported on the work of the National Oceanic and Atmospheric Administrations (NOAAs) so-called 'Blue Ribbon Panel'. This group, including two Nobel laureates, established guidelines for good practices for CV to produce valid estimates of non-use values after an oil spill.

As a technique to value non-market goods or services the contingent valuation (CV) method has been widely used, but not unilaterally accepted. The technique is exposed to considerable criticism regarding the ability to measure individual preferences that are consistent with economic theory. A summary of the most important evidence against and in favour of the method is presented in Carson et al. (2001).

4.1 Design and survey mode

CV surveys are not identical, but a rather basic valuation approach. However, most CV surveys include the following structure (Carson et al., 2001): '(1) an introductory section which helps set the general context for the decision to be made; (2) a detailed description of the good to be offered to the respondent; (3) the institutional setting in which the good will be provided; (4) the manner in which the good will be paid for; (5) a method by which the survey elicits the respondent's preferences with respect to the good; (6) debriefing questions about why respondents answered certain questions the way that they did; and (7) the collection of a set of respondents characteristics including attitudes, debriefing questions, and demographic information.'

One key element of constructing a CV is the choice of elicitation format. The basic approaches available are mainly open-ended questions and di-

chotomous choice question, but also alternatives such as bidding games and payment cards are available (Haab & McConnell, 2002). Open-ended questions ask the responder about a point estimate of the WTP, i.e. something like 'What is the maximum amount you would pay annually for… [the good]? Answer:…'. A dichotomous choice question may read, 'How would you vote if… [the good] costs SEK X per year? □Yes □ No'. Whether to use an open-ended or a dichotomous choice question in CV is still open for discussion (Zweifel et al., 2009). The advantage of dichotomous choice is that valuation of new public goods with coercive payment implies incentive compatibility and also that this format resembles a real market situation. Incentive compatibility implies that 'a truthful response to the actual question asked constitutes an optimal strategy for the agent' (Carson & Groves, 2007). The disadvantage of the dichotomous choice format is that the information from each respondent is limited. We only know whether the WTP is greater or smaller than the bid. In an open-ended question we receive a point estimate.

Methods to collect the data (the survey mode) are mainly (Bateman et al., 2002): (1) mail surveys, (2) telephone surveys, and (3) face-to-face interviews. Also, mixed modes, e.g. mail plus telephone surveys, are possible as well as electronic (e-mail or internet) surveys. Each mode has its pros and cons in terms of costs, control, response rate, and ability to present complex information or visual aids. The NOAA panel (Arrow et al., 1993) recommended face-to-face interviews CV studies regarding natural resource damages. A summary of the advantages and disadvantages of the main survey modes are presented in Table 4.1.

4.2 Potential biases of CV and health surveys

Health surveys in general and CV surveys in particular are liable to certain types of biases. Particular possible biases of CV surveys involves (Mitchell & Carson, 1989): (1) bias caused by reference values and the order of questions (e.g. 'anchoring' effects, starting-point bias, question-order bias), (2) sensitivity to wording of questions (e.g. definition of property rights, means of payment used, description of the good), and (3) attitude towards the object of investigation (e.g. 'yea-saying').

Adding to the specific potential biases of CV, there are also general problems associated with interview studies in the context of health (Zweifel et al., 2009): (1) dealing with small probabilities, (2) emotional rejections of questions, (3) insufficient motivation of the interviewed, and (4) strategic behaviour. Below, we will deepen the empirical background in two areas where the problems have been found to be severe (hypothetical bias and scope insensitivity/embedding). First, we remind ourselves that

Table 4.1 Survey modes

Mode	Advantages	Disadvantages
Mail surveys	Relatively inexpensive	Low response rates 25-50%
	Lack of interviewer bias	Self-selection bias
	Easier to answer sensitive questions	Time-consuming
	Can be completed at respondent's own pace	Little control over who fills the questionnaire
		Fixed question order
		No clarification or probing possible
		Restricts the use of visual aids
		Respondents can alter earlier responses
Telephone interviews	Complex questionnaire structures are possible	No use of visual aids
	Cheaper than personal interviews	Restricts use of lengthy scales
	Permits probing and clarification	Respondents may get tired
	Relatively quick to administer	Respondents may not answer sensitive questions
	Easy to monitor	Non-telephone or non-listed respondents not sampled
	60-75% response rates	
Face-to-face interviews	Highly flexible	Relatively expensive
	Complex questions and questionnaire structures are possible	Interviewer bias
	Permits probing and clarification	Intercept surveys: samples normally not representative and self-selection bias
	Larger quantity of data can be collected	Intercept surveys: questionnaires have to be short
	Potential for extensive use of visual and demonstration aids	
	High response rates 70%+	
	Greatest sample control	

Source: Bateman et al. (2002)

although the problems affect the reliability and validity of WTP estimates from CV studies, it is possible to get an indication of the value for non-market goods. Sufficient theoretical validity has been found in health care applications (Klose, 1999).

4.2.1 Hypothetical bias

Answering hypothetical questions in a CV study may be difficult and lead to differences between actual and hypothetical WTP. This hypothetical bias is found to be a serious problem (Carson et al., 2001; Harrison & Rutström, 2005; Murphy et al., 2005). Harrison (2006) argues that 'assessment of the extent of hypothetical bias is, without a doubt, the most important area of application in the field of environmental valuation.' Several meta-analyses confirm that CV often overstates real economic values by as much as 135 to 300 percent (List & Gallet, 2001; Little & Berrens, 2004; Harrison & Rutström, 2005; Murphy et al., 2005). Researchers are now searching for a way to eliminate or adjust for this bias and, at least, three instrumental approaches have been tested.

The first approach uses follow-up certainty scales. Generally, two versions of the certainty scales have been used (Blumenschein et al., 2008). The first assesses respondents' hypothetical WTP certainty based on a follow-up question with two or more degrees of certainty, i.e. 'probably sure' and 'definitely sure'. In the second version a numerical scale is used, i.e. a 1-10 scale from 'very uncertain' to 'very certain'. In a series of laboratory and field experiments, Blumenschein et al. (1998, 2001, 2008) divided the WTP responses into two degrees of certainty ('probably sure' and 'definitively sure'). Only the 'definitely sure' yes-responses were treated as yes-responses, while the 'probably sure' yes-responses were treated as no-responses. No treatment was carried out with the no-responses. All three studies show a close correspondence between 'definitely sure' yes-responses and real yes-responses, indicating that this can be an effective method to eliminate hypothetical bias.

The numerical version of the certainty approach, a 1-10 or a 0-10 scale, has shown similar results as the 'definitely/probably sure' version (Champ et al., 1997; Johannesson et al., 1999; Champ & Bishop, 2001; Poe et al., 2002; Vossler et al., 2003; Blomquist et al., 2009). When only treating very sure yes-responses as real yes-responses, no significant difference from real WTP values was detected. Yet, the question one has to consider in this version of the certainty approach is how to treat the numerical assessment of uncertainty. If we choose to use a cut-off level of certainty, then where is it large enough, i.e. at 5, at 8 or at 10? Blomquist et al. (2009) examined which values on the 10-point scale give the same estimates of WTP as real

purchases and 'definitively sure' and found that they were always near 10. Other studies has found a cut-off level between 7 and 8 to equalise hypothetical and actual WTP (Ethier et al., 2000; Champ & Bishop, 2001; Poe et al., 2001; Norwood, 2005; Morrison & Brown, 2009).

The second approach is the 'cheap talk' technique introduced by Cummings & Taylor (1999). 'Cheap talk' is applied ex ante and aims at removing bias through better study design and implementation by including an explicit discussion about hypothetical bias. Respondents are informed about hypothetical bias, that it may occur in a hypothetical valuation scenario, provided with numerical examples and are finally asked to adjust their WTP when responding. The cheap talk script may be short, but may also take several minutes to read out loud.

The cheap talk approach has shown mixed results in removing hypothetical bias. Blumenschein et al. (2008) and Morrison & Brown (2009) refer to several studies where the results show that the effectiveness varies and that it can be effective in specific sub-groups. The former authors own field experiment found that mean WTP was about twice as high as real WTP using cheap talk and conclude that it is not generally an effective approach. Morrison & Brown (2009) concluded that cheap talk was less effective than certainty scales and 'dissonance minimisation'. Aadland & Caplan (2006) find that WTP responses are sensitive to cheap talk length as well as contents and suggest caution when using it. In their data from a telephone survey cheap talk rather exacerbate than mitigate the problem of hypothetical bias.

According to Morrison & Brown (2009) cheap talk: 'is most effective when the script presents a compelling case for avoiding hypothetical bias, for public goods where respondents are relatively inexperienced with the good being valued, and for moderate to high bid levels – all contexts where hypothetical bias is likely to be greatest.'

A third approach to adjust for hypothetical bias in estimating WTP is called 'dissonance minimising' (DM) (Blamey et al., 1999; Loomis et al., 1999; Morrison & Brown, 2009). It adds response alternatives to the dichotomous choice and permits respondents to express support for a project without having to vote 'yes', e.g. (Morrison & Brown, 2009):

- I would vote YES to this proposal that everyone contribute $X to… [the project]
- I support the goal of… [the project], but I'm not prepared to pay $X and thus would vote NO.
- I support the goal of… [the project], but I cannot afford $X and thus would vote NO.

• I support the goal of… [the project], but I would prefer to save my money and contribute to another cause and thus would vote NO.
• I support the goal of… [the project], but I would vote NO for the following reason_____.
• I would vote NO to this proposal that everyone contribute $X to… [the project]

As we can see, additional to a 'yes' and a 'no' category (dichotomous choice), DM provides four intermediate categories. When modeling the data, all categories except the first ('yes') are treated as 'no' responses. The results from Morrison & Brown (2009) indicate that less than four additional categories may be needed. Also, DM and certainty scales were found to be most effective in mitigating hypothetical bias. Two disadvantages of the DM format are that it cannot be used with open-ended questions and it has not received much attention in the literature concerning hypothetical bias, i.e. it is largely untested.

In summary, it is increasingly found that incorporating respondent uncertainty can potentially improve the predictive power of CV data. However, all the approaches above can mitigate hypothetical bias if they are calibrated and suited to a given context (Morrison & Brown, 2009). The causes of respondent uncertainty and its implications for valuation are largely unknown (Murphy & Stevens, 2004). Svensson (2009b) estimated the value of a statistical life (VSL) of two Swedish CV surveys and found that age is a significant determinant of certainty, with older respondents expressing higher confidence in their answers. It may therefore be the case that lower VSL values among older respondents are not due to age per se but to less hypothetical bias. The only other study that we know of that investigates the determinants of the certainty levels is Wang (1997), who assumed that individuals' preferences are uncertain and concluded that uncertainty is expected to be large for bids close to real WTP and small for bids decidedly smaller or larger than real WTP.

4.2.2 Insensitivity to scope and embedding

A common approach to test the validity of CV results is to examine whether the results are consistent with economic theory. Much attention and criticism of the technique have focused on the problem of scope insensitivi-

ty and embedding.[1] Especially in the case of valuing low-level changes in health risks, these biases are often found to be severe. Generally, evidence of scope insensitivity has been found in areas other than health (Beattie et al., 1998; Carthy et al., 1999; Jones-Lee & Loomes, 1995).

Historically the problem has been observed ever since the earliest health-related CV studies in the 1970s (Acton, 1973; Robertson, 1977). However, much of the attention of scope bias and embedding emerged in the beginning of the 1990s with two papers by Kahneman & Knetsch (1992) and Smith (1992). The seminal paper by Kahneman & Knetsch (1992) showed that WTP for a narrowly defined good is almost the same as for a much more comprehensive bundle of goods (where the first good is included). They named this phenomenon 'the embedding effect' and concluded that responses to contingent valuation questions reflect WTP for moral satisfaction and should not be mistaken for the economic value of the public good.

In Desvousges et al. (1993) WTPs for covering oil ponds to prevent (i) 2000, (ii) 20 000 or (iii) 200 000 birds from drowning were roughly the same: (i) $80, (ii) $78 and (iii) $88. The large differences in scope should result in sizeable differences in WTP, casting doubt on the validity of CV. However, Carson et al. (2001) criticised this study for suffering from poor design regarding the sampling procedure (executed in a shopping mall) and the way the magnitude of the risk reduction was described (much less than 1 %, less than 1 % and about 2 % of a population of 8.5 million birds).

These papers and other studies (e.g. Hausman, 1993) influenced the National Oceanic and Atmospheric Administration (NOAA) panel report (Arrow et al., 1993) that recommended the use of a scope test to make CV studies acceptable for assessing natural resource damages. In a sense, NOAA's recommendation institutionalised the use of scope tests as the most important validity test of CV. At the same time, the recommendation sharpened the incentives to be very clear on the levels of provision of the valued good in CV, and the scope bias was also further scrutinised.

NOAA's emphasis on insensitivity to scope for changes in small probabilities of health risk further triggered the issue of the amount and type of information to be included in a CV study. Both economists and psycholo-

[1] There exists some terminological confusion in this field; i.e. scope/scale bias, embedding, nesting and part-whole bias are often used synonymously. We adopt the general distinction of Goldberg & Roosen (2007), following Carson & Mitchell (1995), that *scope insensitivity* 'is present when respondents do not sensitively react to the extent of improvements in a single risk to consumer safety but value the risk reduction in general', and *embedding* 'refers to the phenomenon that consumers do not respond adequately to health risk reductions for different diseases or symptoms.'

gists, among others, have struggled with making respondents understand and deal with changes in low-level risks and have put significant efforts into clearly communicating the context at hand since this has proven to reduce these biases (Loomis et al., 1993; Loomis & duVair, 1993). Obstacles to effective risk communication are: '(1) risk information is often highly technical, complex, and uncertain; (2) experts provide widely different risk estimates; (3) regulatory agencies often lack public trust and credibility; (4) there are various ways to define risk; (5) strong beliefs held by the public are resistant to change; and (6) many people have difficulty with probabilistic information' (Loomis & duVair, 1993).

Carson et al. (2001) studied a sample of CV surveys and concluded that: 'Poorly executed survey design and administration procedures appear to be a primary cause of problems in studies not exhibiting sensitivity to scope.' They also listed four design factors that tend to mask sensitivity to scope: (1) vaguely described goods where the descriptions of the goods tend to confuse smaller (part) and larger (whole) goods, (2) questions that emphasise the symbolic nature of the good, (3) questions where the underlying metric on which respondents perceive the larger good is different from that on which respondents perceive the smaller good and (4) differences in the perceived probability of the different goods actually being provided. Although Carson et al. (2001) suggested that most problems with CV can be solved by better design and implementation. They pointed out the area of valuing changes in small probabilities of health risk as the most challenging. However, they saw this field as an active research area in the future and did point to some promising results.

Corso et al. (2001) tested various kinds of visual aids to communicate risk reductions in a better way and found that respondents presented with a logarithmic scale or an array of dots were sensitive to the magnitude of risks, while respondents presented with a linear scale or no visual aid were not. Another test of different visual aids in the same risk context (Loomis & duVair, 1993) showed that the WTP for three different risk reductions were statistically indifferent regardless of whether the respondents were exposed to a risk ladder or a pie chart. Foster & Mourato (2003) concluded that the choice of elicitation format can influence the sensitivity of scope, after finding that choice experiment (CE) values are more sensitive to scope than contingent valuation (CV) values. Goldberg & Roosen (2007) showed that both CE and CV are scope sensitive for single health risks, but that CV is insensitive to multiple disease risks (embedding).

Olsen et al. (2004) investigated the issue of scope insensitivity in the health care area. Both external (between samples) and internal (within samples) scope tests were performed and the result was that no statistically

significant difference in WTP could be detected. They suggested that one possible solution to this problem could be to 'emphasise very strongly the differences in outcomes'. The authors believed that their study was the most systematic scope test on health to date and presented three propositions for further research: (1) a study with larger sample size, (2) tests of the cognitive capacity of the respondents to decide how much information can be included before attention is diverted from the size of the good, and (3) qualitative investigations (focus groups or 'think-aloud' methods) to better understand how preferences are formed.

Heberlein et al. (2005) questioned the routine of making scope tests an important criterion for validity in contingent valuation. The conventional scope test is based on average values and can reveal much more information when studied on an individual basis. By measuring WTP for parts and wholes for four environmental goods and expanding the concept of economic scope to 'attitudinal' and 'behavioural' scope, Heberlein et al. (2005) showed that failures to pass a scope test can be explained through psychological and economic theory. They concluded that the scope test as the only test of validity should be questioned and that comparing the mean values can lead to both false positives and false negatives.

5. Purpose of thesis

This thesis contains six separate papers and the main purposes can be summarised as follows:

1. To estimate the value of a statistical life (VSL) for out-of-hospital cardiac arrest (OHCA) victims. We build on experiences from VSL estimates regarding transport safety and extend it to a new context.

2. To explore methodological issues in the use of the stated-preference technique contingent valuation (CV). Focusing on the two problematic areas presented in Sections 4.2.1 and 4.2.2, hypothetical bias and insensitivity to scope/embedding, we seek explanations and possible solutions for them.

3. To evaluate the effects of dual dispatch defibrillation by ambulance and fire services in the County of Stockholm by using a cost-benefit analysis. We also explore how different response times from OHCA to defibrillation in the same geographic area affect patients' survival rates. This was done by combining a geographic information systems (GIS) simulation of driving times with register data on survival rates.

4. To analyse demographic determinants of incident experience and risk perception, as well as the relationship between the two, for different risk domains.

6. Summary of thesis

6.1 Paper I: The value of a statistical life for out-of-hospital cardiac arrest victims

The first paper examines the value of a statistical life (VSL) for out-of-hospital cardiac arrest (OHCA) victims based on the stated-preference technique contingent valuation (CV). CV is a survey-based stated preference technique that is used to directly elicit individuals' hypothetical willingness to pay (WTP) for certain non-market goods or services. Since the individuals who suffer OHCAs are generally older and less healthy than people who die in road traffic accidents, we expect VSL to lower for the former group (a 'senior death discount').

Contrary to our expectations, we found VSL values to be higher for OHCA victims and a lower-bound estimate of VSL for OHCA would be in the range of 20 to 30 million Swedish crowns (SEK). The results in this paper indicate that it is not an overestimation to use the 'baseline' VSL value from the transport sector (SEK 22 million) in cost-benefit analysis of OHCA policy decisions. Our results do not support the practice of decreasing VSL with age for victims of cardiac arrest, i.e. no 'senior death discount' for this cause of death.

6.2 Paper II: Does the within-difference between dichotomous choice and open-ended questions measure certainty?

The second paper concerns hypothetical bias in contingent valuation (CV) studies. Calibration may remedy overstatement of willingness to pay (WTP), but little research has been done to find a link between the determinants and empirical treatment of uncertainty through certainty calibration. We use a combination of dichotomous choice (DC) and an open-ended (OE) question in two CV surveys to examine the relation between the degree of confidence and the distance between the DC bid and the OE answer.

The results show that the OE-bid difference is significantly correlated to the certainty level in one of our two contingent valuation (CV) surveys. The probability of stating the highest confidence value increased by 5-19 per cent per SEK 1000 (~$170/€106, exchange rates: $1 = SEK 7.43, €1 = SEK 9.51; 14 Sept. 2010) that the answer to the OE question and the bid differed. The second CV survey shows a significant relation for no-responders. Our results mainly strengthen the theoretical arguments of the certainty approach, i.e. the higher the confidence of the respondents the more we can trust that stated WTP is correlated to actual WTP.

6.3 Paper III: Sensitivity to scope in contingent valuation – testing two aids to communicate mortality risk reductions

The third paper investigates the performance of two communication aids (a flexible community analogy and an array of dots) in valuing mortality risk reductions for out-of-hospital cardiac arrest (OHCA). The array of dots has been shown to be strongly sensitive to the magnitude of risks in other risk domains and should therefore be an appropriate benchmark. FCA is a modified communication aid that has not been applied before. It presents the respondents with a matrix where the rows represent different municipality sizes (10 000-750 000 inhabitants) and the columns report (i) the number of individuals who experience OHCA, (ii) the current survival rate of OHCA patients, (iii) the hypothetical improved survival rate and (iv) the absolute difference between (ii) and (iii).

We present the results of a contingent valuation mail survey conducted in Sweden for the purpose of testing the sensitivity to the size of the risk reduction predicted by standard economic theory, i.e. (i) WTP increases with the amount of risk reduction and (ii) WTP is approximately proportional to the magnitude of risk reduction. The results do not support the prediction of expected utility theory, i.e. that WTP for a mortality risk reduction increases with the amount of risk reduction (weak scope sensitivity), for any of the communication aids. In fact, the array of dots even shows a decreasing WTP when the risk reduction is larger. Additionally, we find some evidence that level of education influences how the communication aids are perceived.

6.4 Paper IV: Favourable cost-benefit in an early defibrillation programme using dual dispatch of ambulance and fire services in out-of-hospital cardiac arrest

The fourth paper presents a cost-benefit analysis to evaluate the effects of dual dispatch defibrillation by ambulance and fire services in the County of Stockholm, Sweden. The increased survival rates were estimated from a real-world implemented intervention, and the monetary value of a life (€ 2.2 million) was applied to this benefit by using results from a recent stated-preference study (paper I). The estimated costs include defibrillators (including expendables/maintenance), training, hospitalisation/health care, fire service call-outs, overhead resources and the dispatch centre.

The estimated number of additional saved lives was 16 per year and the intervention had positive economic effects, yielding a benefit-cost ratio of 36, a cost per quality-adjusted life-year (QALY) of € 13 000 and the cost per saved life was € 60 000. For the cost-benefit analysis the return on

investment was high and the cost-effectiveness showed levels below the threshold value for economic efficiency used in Sweden. The cost-utility analysis categorises the cost per QALY as medium.

6.5 Paper V: Effect of response times on survival from out-of-hospital cardiac arrest: using geographic information systems

The fifth paper explores how different response times from out-of-hospital cardiac arrest (OHCA) to defibrillation in the County of Stockholm, Sweden, affect patients' survival rates. This was done by combining a geographic information systems (GIS) simulation of driving times with register data on survival rates. The emergency resources comprised ambulance alone and ambulance plus fire services.

The simulation model predicted a baseline survival rate of 3.9 per cent, and reducing the ambulance response time by one minute increased survival to 4.6 per cent. Adding the fire services as first responders (dual dispatch) increased survival to 6.2 per cent from the baseline level. The predicted outcome of the model (16 additional survivors) showed good compliance with empirical data from a 'real world' project (16 additional survivors). The possibility of testing where defibrillators should be placed geographically is deemed particularly useful.

6.6 Paper VI: Demographic determinants of incident experience and risk perception – do high-risk groups accurately perceive themselves as high-risk?

The sixth paper analyses demographic determinants of incident experience and perception of risks, as well as the relationship between the two, for the following eight different risk domains: (A) fire accidents, (B) burglaries and thefts, (C) falling accidents, (D) electricity accidents, (E), road-traffic accidents, (F) drowning accidents, (G) violence and abuse, and (H) natural disasters (e.g. a flood). Analyses are conducted by merging the results of a Swedish population-based survey, which includes approximately 15 000 individuals, with demographic and economic register data.

We find that being male is associated with higher incident experience yet a lower risk perception for nearly all risk domains. Lower socioeconomic status is associated with high incident experience for violence and falling accidents, but lower incident experience for road traffic accidents. For risk perception, lower socioeconomic status is associated with higher risk perception for falling accidents. On aggregate, ranking the different domains, respondents' risk perception is almost in perfect correspondence to the ranking of actual incident experience, with the exception that the risk vio-

lence is ranked higher than indicated by actual incident experience. On a demographic group level, males and highly educated respondents perceive their risks to be lower than what is expected considering their actual incident experience.

Table of abbreviations

Abbreviation	***Meaning***
CBA	Cost-benefit analysis
CE	Choice experiment
CEA	Cost-effectiveness analysis
CUA	Cost-utility analysis
CV	Contingent valuation
GIS	Geographic information systems
OHCA	Out-of-hospital cardiac arrest
QALY	Quality-adjusted life years
RP	Revealed preferences
SP	Stated preferences
VSL	Value of a statistical life
WTA	Willingness to accept
WTP	Willingness to pay

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