Report of Considerations of the Meta-analysis Work Group: Synthesis of VSL Estimates

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Work Group Process

In early 2005, staff at the EPA NCEE decided that meta-analysis might be useful in a reassessment of VSL and contacted Olkin. Olkin contacted Becker and a meeting was arranged, wherein the potential of meta-analysis for addressing the NCEE's problem was to be discussed.

> Meta-analysis is a process whereby results from series of independent studies are synthesized and variation in results is examined. Typically the studies report estimates of a meaningful parameter measured similarly across studies.

In order to move from the abstract to practical consideration of meta-analysis for VSL, it was decided to have a group of experts examine the existing meta-analyses regarding VSL.

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Work Group Process

July, 2005	Becker and Olkin met with EPA staff
October, 2005	Invitations were issued to six experts on meta-analysis to join the work group
December, 2005	Group met in Washington, heard presentations on three meta-analyses, and began to draft a report
December, 2005 – March, 2006	Report draft competed, submitted for feedback, and revised

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Meta-analyses Considered by the Work Group

Three meta-analyses were examined:

Kochi, Ikuho, Bryan Hubbell, and Randall Kramer, An Empirical Bayes Approach to Combining and Comparing Estimates of the Value of a Statistical Life for Environmental Policy Analysis, *Environmental and Resource Economics*, May 2006, Pages 1 - 22, DOI 10.1007/s10640-006-9000-8.
URL http://dx.doi.org/10.1007/s10640-006-9000-8

Mrozek, Janusz R. and Laura O. Taylor. 2002. What Determines the Value of Life? A Meta-Analysis. *Journal of Policy Analysis and Management* 21(2): 253-270.

Viscusi, W. Kip and Joseph E. Aldy. 2003. The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World. *Journal of Risk and Uncertainty* 27(1): 5-76.

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Charge Questions for Meta-analysis Work Group

These questions were considered in the review of the use of meta-analysis with the value of statistical life (VSL) literature. We will address each in turn.

A. Policy Issues

How can meta-analysis provide estimates of VSL for use in EPA policy?

B. Methodological Questions

1. Are there other methods that combine studies that would provide VSL estimates that could be used in EPA policy?

2. How can multiple meta-analyses be combined when the same studies appear in different meta-analyses?

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Charge Questions for Meta-analysis Work Group

C. Modeling Issues

1. When several different models of value of statistical life (VSL) estimates are presented in a single study, should one model (and therefore, one estimate) be selected and if so, how? Or, should multiple estimates be used from each study?

2. When several sub-samples in one study provide VSL estimates, should they be combined or entered as separate estimates into the meta-analysis?

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Charge Questions for Meta-analysis Work Group

D. Moderators

If moderator analyses identify significantly different estimates (e.g., by study design, population, over time, etc.), should those estimates be combined and if so, how should a single estimate be computed?

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Charge Question A

A. Policy Issues
How can meta-analysis provide estimates of VSL for use in EPA policy?

Given consideration of the three syntheses and related discussions, the work group agreed that, in theory, meta-analysis can be a viable tool for synthesizing information about VSL for the EPA.

Two key questions are whether the existing available studies of VSL are of suitable quality for the EPA, and whether they provide sufficient information to allow for synthesis. The nature of the studies of VSL will determine whether meta-analysis can be used.

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Charge Question A

Meta-analysis requires standardized study outcome indices and information on sample size.

- For example, in medical studies of survival vs. death, all studies must provide proportions or counts of patients in these two categories, as well as total sample sizes.

- Syntheses of studies of mean differences require means, SDs, and sample sizes, from which standardized mean differences are computed.

A key issue is that the indices must have “the same” meaning across studies or it will not make sense to combine them.

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Charge Question A

Syntheses of regression results require

- sample sizes,
- slopes for predictor-outcome relations,
- SEs, and, optimally,
- covariances among the slopes.

The predictors and outcomes must be measured using similarly scaled instruments and variables, and should arise from models that include very similar sets of predictors.

To the extent these conditions do not hold, statistical issues will arise about comparability, and the outcome indices may not be interpretable if synthesized.

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Charge Question B.1

B. Methodological Questions

1. Are there other methods that combine studies that would provide VSL estimates that could be used in EPA policy?

It was not clear that any other methods could provide similar information. Systematic reviews consider available studies, often including lists of study outcomes, but do not use statistical analyses to synthesize and analyze those study outcomes.

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Charge Question B.2

B. Methodological Questions

2. How can multiple meta-analyses be combined when the same studies appear in different meta-analyses?

In the group's view it would not be wise to combine results from existing meta-analyses.

The primary problem with combining meta-analyses is that some studies will appear in several meta-analyses, thus

- the data will be dependent and
- duplicated studies will have undue influence on combined results.

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The Later Charge Questions (C and D)

The remaining charge questions concerned the conduct of meta-analyses on VSL.

To address these questions the work group discussed the meta-analyses on VSL and considered them in relation to the literature on methods for meta-analysis.

Several key issues were elucidated via discussion of the modeling-issue and moderator charge questions. Some issues were determined not to be statistical issues, but rather are substantive issues fundamental to the conceptualization of VSL and the nature of research on VSL.

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Guidelines for Meta-analysis

Guidelines have been proposed (mainly in the literatures of medical research) that specify several areas that need to be addressed in the conduct and reporting of meta-analyses. These can inform us about questions C and D.

Issues can be raised in each of these areas for meta-analyses on the topic of risk valuation. These areas are:

- Background of the Problem
- Search Strategies and Inclusion Rules
- Coding of Results and Study Features
- Analyses
- Discussion and Conclusions

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Background of the Problem

In any meta-analysis the data to be synthesized and methods most appropriate for the synthesis are determined in part from the problem being addressed. In medical reviews protocols are used to define the problem under study prior to the conduct of the synthesis.

In the context of VSL it was not clear to the work group if the goal is to estimate is a single overall (average) value of VSL or whether a set of VSL values might be of interest.

The meta-analyses examined by the workgroup appear to admit to the possibility that there is a collection of VSL values. The best approach for data analysis will depend on which of these views is adopted.

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Search Strategies and Inclusion Rules

Explicit search and inclusion/exclusion rules allow readers to assess the thoroughness of data collection and the representativeness of the set of synthesized studies. This is particularly critical when several syntheses have been conducted, but appear to use different sets of studies.

The meta-analyses examined by the workgroup appear to be fairly explicit on inclusion/exclusion rules but they do not give clear descriptions of how the studies were identified to begin with.

The use of search rules can help to clarify differences in the populations to which inferences apply.

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Coding of Results and Study Features

Many issues were evident in this area. Meta-analyses should explore whether study features may be sources of differences in the values of VSL. Several key features are

- the two study designs from which VSL estimates are drawn (hedonic wage (HW) and contingent valuation (CV) studies),
- the metric in which wages are expressed,
- the metric for risk itself,
- the other variables included in models involving VSL,
- the populations for which VSL was evaluated.

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Charge Questions for Meta-analysis Work Group

C. Modeling Issues

1. When several different models of value of statistical life (VSL) estimates are presented in a single study, should one model (and therefore, one estimate) be selected and if so, how? Or, should multiple estimates be used from each study?

A fundamental requirement of meta-analysis is that indices be independent (or that adjustments for dependence be used). Thus if multiple models are based on a single data set only one index should be drawn from the models.

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Charge Questions for Meta-analysis Work Group

C. Modeling Issues

2. When several sub-samples in one study provide VSL estimates, should they be combined or entered as separate estimates into the meta-analysis?

Again the concern here is whether the data are independent. If subsamples do not overlap, then the indices drawn from those subsamples will likely be independent and can be entered as separate estimates.

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Additional Concerns Regarding Analyses

Complications in summarizing slopes from different models. Slopes (or functions of slopes such as VSL values) arising from different models may require different interpretations. Often such differences are marked with indicator variables entered into meta-regressions, but this process has not been studied for combinations of regression results.

Weighting. Some of the VSL meta-analyses used weighting (e.g., Kochi et al.), which is a standard part of the process in most meta-analyses. Weighting incorporates differences in precision of the estimates being combined and should be used if possible.

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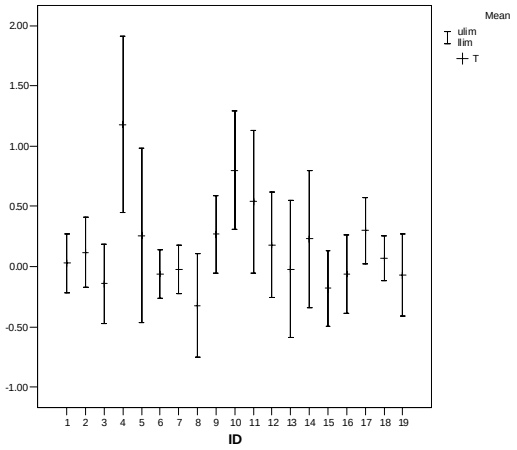
Additional Concerns Regarding Analyses

Use of standard graphical techniques.
In typical meta-analyses graphical techniques are used to explore variation in study results and reveal uncertainty. The VSL meta-analyses could benefit from such graphs.



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Additional Concerns Regarding Analyses

Publication bias. This is the effect that occurs when non-significant results are not published and when only published results are included in meta-analyses. Typically publication bias leads to overestimates.

It is not clear whether unpublished papers are included in all 3 VSL syntheses (search processes are not described) but if they are not, overestimates of VSL are likely.

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Work Group Conclusions: General Comments

I.1. If the underlying collection of studies provides good evidence about VSL, then meta-analysis is an appropriate methodology for examining the results of that collection of studies.

I.2. The work group does not recommend combining the results of existing meta-analyses.

This relates to point I.4 and is based on the need to have independent sources of data to meet the assumptions of meta-analytic methods, and to avoid excessive influence if some studies appear in multiple meta-analyses.

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Work Group Conclusions: General Comments

I.3. Hedonic wage and contingent valuation methodologies appear to yield distinctly different estimates of VSL. Thus the work group recommends that studies using these two approaches be analyzed separately.

This conclusion is based on the idea that the goal of a synthesis is to assess similarities among results and to combine when appropriate (which means when results are reasonably consistent). If results from different study designs differ widely then combining them can lead to an overall result that has relevance for no situations at all.

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Work Group Conclusions: General Comments

I.4. Multiple VSL estimates from the same study, and therefore from the same data set, should be combined cautiously or not at all.

Studies that use the same data and similar analytic methods should *not* contribute several VSL estimates to one meta-analysis. It is often preferable to choose one best index from each study (or possibly each independent data set) for use in the meta-analysis.

If results are based on independent subsets of subjects (e.g., blue collar workers vs. white collar workers) the VSL estimates may be independent and if so can be combined.

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Work Group Conclusions: General Comments

I.5. Bias considerations should be addressed in the reporting of a meta-analysis. The work group recommends that quality considerations be addressed in a protocol for any further meta-analysis.

Because methods vary across studies of VSL, the work group assumed that some methods variation might be related to differences in quality that are not purely statistical issues. For instance the scaling of wages varies (wage, log(wage)) as do measures of mortality risk (e.g., self-report versus objective risk measures, etc.).

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Work Group Conclusions: General Comments

I.6. Because there is variability among individuals in valuing mortality risk, an "average" value may smooth effects. Analyses focusing on percentiles or other indices characterizing a distribution of VSL values may reveal variations across different segments of the population.

In meta-analyses random-effects (RE) models and analyses admit to and account for the existence of a population of effects (e.g., of true VSL values).

If a single value is estimated when the data suggest that a population of VSL effects exists, the estimate of the average effect must incorporate the uncertainty resulting from variation in the true effects (this is the RE average).

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Work Group Conclusions: General Comments

I.7. Risk is an elusive concept, especially when risks are very small. Risk reduction is often examined for small values, and may be difficult to estimate. Alternative metrics for risk, as well as for VSL estimates, should be investigated by EPA. This is not solely a statistical issue.

I.8. Sufficient ambiguities in procedures for estimating VSL exist, which leads the work group to strongly recommend a full-scale study wherein HW and CV methods would both be used and compared directly.

I.9. Geographic considerations (e.g., whether to include foreign studies) should be decided upon *a priori*.

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Work Group Conclusions: Statistical Issues

II.1. When combining estimates of VSL, each VSL estimate should be weighted by the reciprocal of its variance or squared standard error.

The statistical properties of most meta-analytic estimates require weighting to accommodate the often unequal precisions of individual data points (here, the VSL estimates).

II.2. Confidence intervals should be provided for individual VSL estimates, and for the combined VSL value.

This is standard practice in most meta-analyses and allows for consideration of imprecision and examination of undue influence of particular results.

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Work Group Conclusions: Statistical Issues

II.3. Explanatory, study level or VSL-estimate level variables, when used, should be included in one model and not in separate subgroup analyses.

It is possible and advisable to conduct relatively comprehensive modeling analyses using weighted analogues to regression, often labeled “meta-regressions.” Because study features can be confounded in meta-analyses, running such overall models avoids excessive Type I error and allows for the examination of multi-collinearity and other assumptions.

II.4. Graphics should be included whenever a regression model is used, as for example, plots of residuals and scatter plots of the X-Y relations.

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Work Group Conclusions: Statistical Issues

II.5. Regression methods are available as macros for SAS, SPSS and Stata, in Comprehensive Meta-Analysis (CMA) and in programs such as HLM, MLWin and HBLM (see also BUGS).

For example, Stata has available a number of user-provided routines for meta-analysis. One of these, "metareg," is specifically designed to perform the sort of meta-regressions being proposed.

These analytic packages make possible the standard use of meta-regression techniques.

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Statistical Issues (Unresolved or for Future Research)

II.6. Multiple analyses should be presented to justify the interpretation of results from meta-regressions. For instance, in fitting distributions, analyses of hazard or failure rates may enable the meta-analyst to detect inconsistencies in slope values.

II.7. EPA should study the use of Huber weights to address the problem of variable dependence. (Huber-White weights were used to obtain robust standard errors in the meta-analysis by Mrozek and Taylor.) The work group was unclear on the details of this method as it applies in this context.

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