Valuing mortality risk reductions for policy:

Proposed updates to valuation and income elasticity estimates

EPA presentation to Science Advisory Board Environmental Economics Advisory Committee

March 7, 2016

Overview

Assembling Data for Mortality Risk Valuation

- Selection criteria
- Deriving population estimates

Methodology

- Estimation approach
- Selecting estimates from results

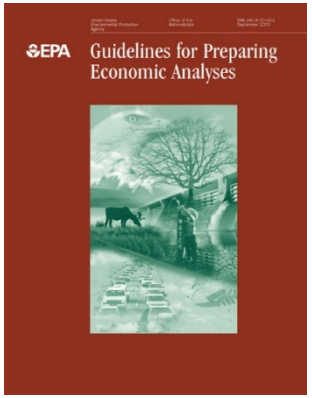
Income Elasticity

- Treatment of very low, non-zero, mean reported income elasticity results
- Selection criteria
- Application to non-fatal health risks

Updating VSL Estimates

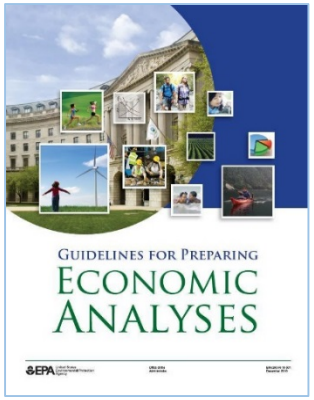
Existing EPA guidance recommends a VSL estimate of **$9.7 million** ($2013):

- Based on 21 **hedonic wage** studies and 5 **stated preference** studies published between 1974-1991
- Developed for *812 Retrospective Study of the CAA* in 1997
- Codified in 2000 *Guidelines;* Not updated in 2010 revision of *Guidelines*



Application of SAB recommended screening criteria yields studies published between 1999-2014 including

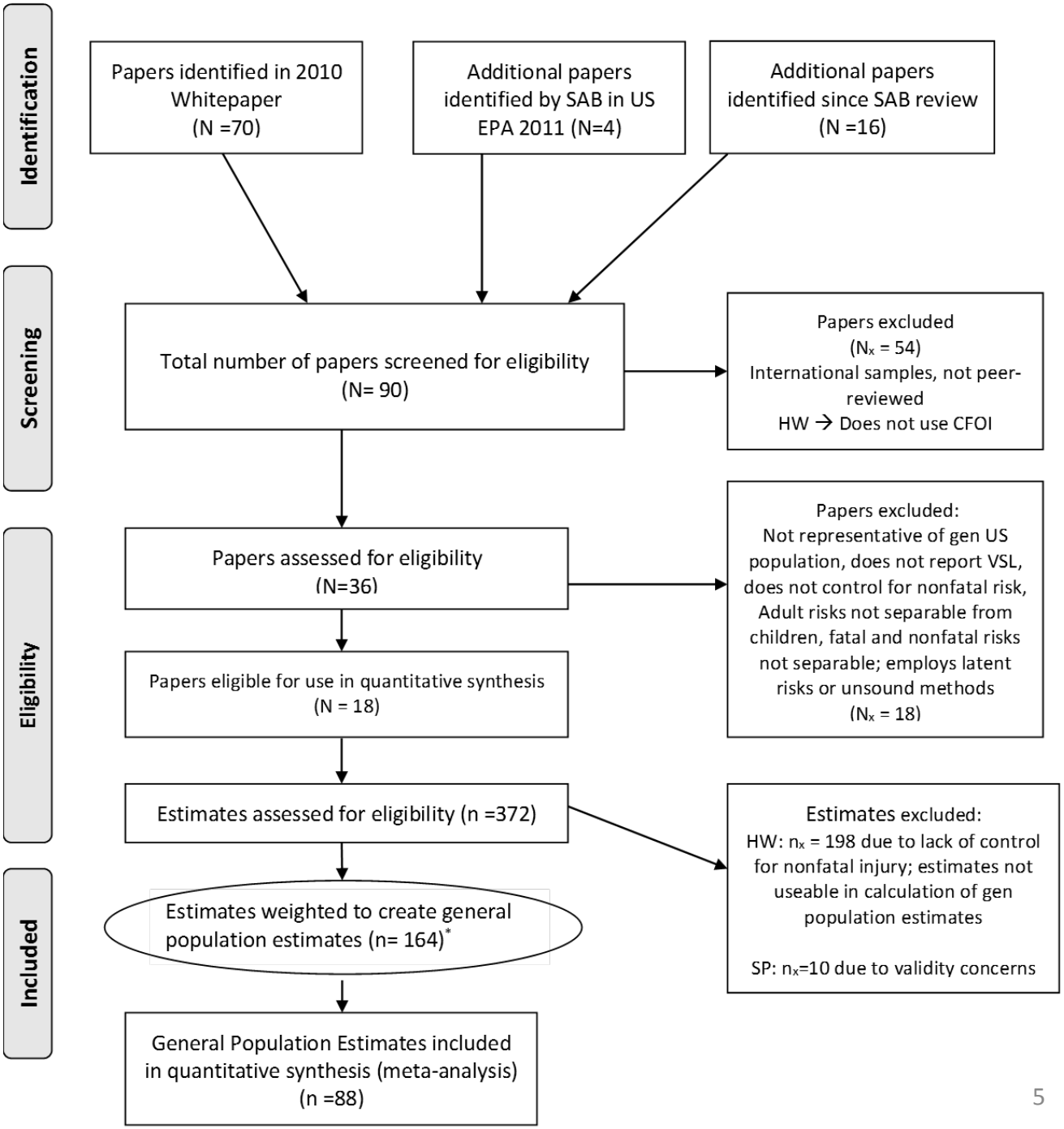
- 9 stated preference studies (28 estimates)
- 8 hedonic wage studies (46 estimates)



Selection Criteria (SAB 2011)

Common to both study types	
	Conducted in the U.S.
	Representative of populations affected by EPA regulations
	Include all estimates based on conceptually sound methods
	Published in peer-reviewed literature
	Provide enough information to calculate a VSL estimate if one is not reported
	Written in English
Stated Preference	**Hedonic Wage**
Provide estimates of willingness to pay (as opposed to willingness to accept)	Use adequate measures of occupational risks (defined by SAB as use of Census of Fatal Occupational Injuries or equivalent)
Provide quantitative information about uncertainty in estimates	Exclude studies based extremely dangerous jobs
Provide evidence of validity (e.g., evidence of responsiveness to scope)	Control for nonfatal injury risk
Include estimates for adults only	Control for unobserved job characteristics using industry and occupational indicator variables
	Does not rely on risk measures constructed at the industry level only

PRISMA Diagram for VSL estimate selection



PRISMA: Preferred Reporting Items for Systematic reviews and Meta-Analyses

Selected Charge Questions on Data Assembly

1a. Evidence of validity for stated preference studies: selected stated preference studies "should provide evidence that it yields valid estimates" (page 16).

In applying this criteria, EPA included studies and estimates that passed a weak scope test or provided other evidence of validity.

1b. Construct of the risk variable in hedonic wage studies: "Eliminate any study that relies on risk measures constructed at the industry level only (not by occupation within an industry)" (U.S. EPA Science Advisory Board 2011, page 18).

In applying this criteria, EPA included studies and estimates where the risk measure is differentiated by industry and at least one other characteristic (e.g., occupation, gender, age).

1c. Estimates for immediate risk reductions: EPA selected estimates from the stated preference literature that are most closely comparable to the accidental deaths from the hedonic wage literature.

The EPA made judgement calls …

Viscusi, Huber and Bell (2014) estimate reductions in risk of bladder cancer that will occur in 10 years. Use author-discounted estimates as comparable to an immediate risk reduction.

Alberini, et al. (2004) estimate a willingness to pay for an annual reduction in risk over 10 years.

3. General population estimates: Some estimates in the meta-analysis dataset in the White Paper are constructed by weighting subpopulation-specific estimates within a study in order to approximate an estimate for the general population.

Estimation Approach

- We used meta-analysis and meta-regression approaches to estimate the average VSL among the U.S. adult general population.

- Some studies contribute multiple observations to the meta-database.

- We accounted for sampling and non-sampling errors. [Q7]
  - Sampling error variances assumed equal to reported standard errors for each observation.
  - Within-study non-sampling error variances assumed equal across studies.
  - Non-sampling error variances were estimated using the data.

- We focus on estimators with highest efficiency. [Q9]

Estimation Approach

META-ANALYSIS: [Q5]

Weighted means: $\hat{y} = \sum_{i=1}^{I} \sum_{j=1}^{m_i} w_{ij} y_{ij}$

Weighting scheme	w_{ij}
Simple mean	$1/N$
Mean of group means	$1/(Im_i)$
Sample size weighted mean	$\frac{n_{ij}}{\sum_{i=1}^{I} \sum_{j=1}^{m_i} n_{ij}}$
Sampling error variance weighted mean	$\frac{se_{ij}^{-2}}{\sum_{i=1}^{I} \sum_{j=1}^{m_i} se_{ij}^{-2}}$
Total error variance weighted mean [Q7]	$\frac{\left(m_i \hat{\sigma}_\eta^2 + \hat{\sigma}_\mu^2 + se_{ij}^2\right)^{-1}}{\sum_{i=1}^{I} \sum_{j=1}^{m_i} \left(m_i \hat{\sigma}_\eta^2 + \hat{\sigma}_\mu^2 + se_{ij}^2\right)^{-1}}$

y_{ij} = observation *j* in group *i*

w_{ij} = weight placed on observation *j* in group *i*

N = number of observations

I = number of groups

m_i = number of estimates in group *i*

n_{ij} = sample size used to estimates observation *j* in group *i*

se_{ij} = standard error of observation *j* in group *i*

$\hat{\sigma}_\eta^2, \hat{\sigma}_\mu^2$ = estimated between and within group non-sampling error variances

Estimation Approach

<u>META-REGRESSION</u>: [Q8]

Assume "data generating process" is:

$$y_{ij} = \beta_0\left(1 + \beta_{SP} d_{SP,ij}\right)\left(1 + \beta_{median} d_{median,ij}\right) + \beta_{year} t_{ij} + \eta_i + \mu_{ij} + \varepsilon_{ij},$$

where all error terms are independent and normally distributed:

$$\eta_i \sim N\left(0, \sigma_\eta^2\right),\ \mu_{ij} \sim N\left(0, \sigma_\mu^2\right), \text{ and } \varepsilon_{ij} \sim N\left(0, se_{ij}^2\right).$$

Use maximum likelihood to estimate σ_η^2, σ_μ^2, and the constituents of β.

Selected Charge Questions on Estimation Approach

5. "Please comment on whether the **methodology** used in the White Paper to analyze the data represents an appropriate and scientifically sound application of meta-analytic methods…"

6. "The White Paper classifies estimates into independent samples, also called **groups**…"

7. "…the White Paper presents an expression that characterizes optimal **weights that account for sampling and non-sampling errors**…"

8. "…the White Paper adopts both **non-parametric** and **parametric** approaches…"

Estimation Results

Table 7. Non-parametric estimates of the average VSL among the U.S. adult general population (2013$/statistical life/yr). Assuming income elasticity = 0.7. “m” includes only mean estimates, “mm” includes both mean and median estimates. Values in square brackets are bootstrapped standard errors.

Estimator	mm/m	HW	SP	pooled	balanced
simple mean	mm	11.9 [1.13]	7.53 [1.00]	9.83 [1.20]	9.73 [0.753]
	m	11.9 [1.13]	8.59 [1.91]	10.7 [1.29]	10.3 [0.969]
mean of group means	mm	10.4 [0.378]	7.86 [0.724]	9.01 [0.460]	9.11 [0.408]
	m	10.4 [0.378]	10.4 [1.15]	10.4 [0.587]	10.4 [0.545]
sample size weighted mean	mm	11.8 [1.25]	7.96 [1.25]	11.8 [1.27]	9.90 [0.880]
	m	11.8 [1.25]	8.67 [1.85]	11.8 [1.26]	10.3 [1.01]
sampling var. weighted mean	mm	9.27 [1.01]	6.65 [2.99]	6.69 [2.93]	7.96 [1.56]
	m	9.27 [1.01]	9.49 [3.34]	9.48 [3.13]	9.38 [1.76]
total var. weighted mean	mm	10.1 [0.396]	7.09 [0.829]	8.55 [0.640]	8.59 [0.461]
	m	10.1 [0.396]	8.28 [1.31]	9.42 [0.672]	9.19 [0.684]

[Q9]

Estimation Results

Table 9. Maximum likelihood estimation results. Values in square brackets are asymptotic standard errors.

Parameter	HW	SP	pooled	balanced
β_0	10.7 [0.556]	9.66 [1.08]	10.1 [0.718]	11.0 [1.00]
β_{year}	1.59 [0.485]	1.18 [0.925]	1.13 [0.596]	1.33 [0.588]
β_{SP}				-0.147 [0.112]
β_{median}		-0.482 [0.101]	-0.479 [0.0852]	-0.451 [0.095]
σ_μ	1.33 [0.628]	2.24 [0.349]	2.12 [0.287]	2.10 [0.288]
σ_η	0.458 [0.924]	2.65 [0.702]	2.20 [0.460]	2.03 [0.468]
VSL_{HW}	10.7 [0.556]			11.0 [1.00]
VSL_{SP}		9.66 [1.08]		9.36 [0.937]
VSL_{pooled}			10.1 [0.718]	
$VSL_{balanced}$				10.2 [0.702]

[Q9]

Charge Question 9

The White Paper proposes the use of an average estimate of $10.3 from the following models:

- Non-parametric model, balanced, mean of study mean (VSL = $10.4)
- Parametric, balanced…" (VSL = $10.2)

Non-parametric model:

- All weighted means should be unbiased, therefore **we choose the estimate with the lowest estimated variance (i.e., $10.4)**
- While the weighted mean uses no parametric assumptions, it is only based on <u>mean</u> VSL observations (i.e., median estimates are excluded).

Parametric model:

- ML uses all observations in the meta-dataset (i.e., means and medians), but requires parametric assumptions about the form of the relationship between the control variables and VSL estimates and the distributions of the error components.
- **We choose the estimate from the balanced model to give equal weight to SP and HW estimates (i.e., $10.2)**

Income Elasticity

- Commissioned review by Industrial Economics, Inc. (Robinson and Hammitt)
- Applied similar selection criteria to identify studies, but a very limited literature (<10 VSL studies)
- Qualitative analysis suggests two alternatives

Option	Central Estimate	Reasonable Bounds	Notes
(1) Equally weight mean results from HW & SP literatures	0.7 (weighted mean)	0.1, 1.4 (lowest and highest reported mean values)	Consistent with "balanced" approach to VSL estimation
(2) Use HW meta-analysis solely (i.e., Viscusi, 2015)	1.1 (random-effects model, preferred specification)	0.6, 1.7 (central value +/- clustered standard error)	From Robinson & Hammitt (2015)

Notes for Option 1: Trimming the dataset to remove two very low estimates from Hammitt and Haninger (2010) and Viscusi, Huber, and Bell (2014) still yields a rounded central value of 0.7, but changes the reasonable bounds to 0.3 to 1.4.

Income Elasticity

- Limited literature
  - < 10 studies met criteria for mortality risk
  - Very few for estimates for non-fatal risks

- Key questions and judgments
  - Charge Q 16: *"…Of these alternatives which is the most appropriate and scientifically sound?'*
  - Charge Q 14: "*The "balanced" approach… does not include reported mean estimates of zero, but does include very low reported mean estimates…"*
  - Charge Q 17: *"…using the IEVSL to estimate income elasticity for the [income elasticity of WTP for] non-fatal health risks…"*

Thank you!