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# Review of Health Endpoints and Economic Valuation for Socioeconomic Report on 2016 South Coast AQMP

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# Presentation Overview

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- Valuation Review
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    - Results and Recommendations

# Approach to Health Endpoint Review

- Identified endpoints and studies from most recent SCAQMD Socioeconomic Report and USEPA ISAs or RIAs.
- Supplemented with literature search (PubMed, Google Scholar) covering more recent studies.
- Reviewed against criteria discussed previously for quality, relevance, geographic scope.
- Focused on high-quality local studies where available.

# Criteria – Epi Studies/Health Literature

**CRITERIA**

**GENERAL:**

1. Study is peer-reviewed.
2. Study is written in English.
3. Study measures exposure to at least one of the following pollutants: $O_3$, $PM_{2.5}$, $PM_{10}$, $NO_x$, $SO_2$,
4. Preference given to studies or groups of studies that significantly advance our understanding of the relationship between air pollution exposures and mortality and morbidity endpoints, including those endpoints previously quantified by the SCAQMD in its Air Quality Management Plans as well as new endpoints.
5. Study was published within the following timeframes:
    a. $PM_{2.5}/PM_{10}$: 2012 – present
    b. $NO_2$: 2012 – present
    c. $O_3$: 2007 – present
    d. $SO_2$: 2003 - present

**GEOGRAPHY AND STUDY POPULATION:**

6. Study measures exposures at or near ambient levels found in the South Coast Air Basin. Order of preference of study location:
    a. South Coast Air Basin (Los Angeles, Orange, Riverside, and San Bernardino Counties)
    b. Within State of California
    c. Within Western United States
    d. Within United States or Canada
7. Study uses study population with similar characteristics as found in Los Angeles, Orange, Riverside, and San Bernardino counties.

**STUDY DESIGN:**

8. Study is population-based, preferably using cohort and case-control epidemiological study designs. Controlled human exposure studies may be evaluated for supporting evidence. Animal and in-vitro studies excluded.
9. Study controls for factors that may obscure the true concentration-response relationship, including selection bias, misclassification, recall bias, confounding (including by other pollutants), effect modification, mortality displacement, loss to follow-up, etc.
10. Study appropriately assesses any potential lag between exposure and outcomes.
11. Study appropriately assesses any potential exposure thresholds for health outcomes.
12. Study clearly presents information about uncertainty in results to facilitate evaluation and comparison with other studies.
13. Prefer studies that assess changes in the risk of incidence of disease, rather than exacerbation of existing cases or changes in symptoms.

# Results for PM Mortality

- Recommend a pooling of three LA-specific estimates: Krewski et al., 2009; Jerrett et al., 2005; and Jerrett et al., 2013.
  - All based on well-studied ACS cohort data.
  - Common study area.
  - Each employs a different exposure assessment.
  - Extensive control for confounding.
  - More recent exposure data than other LA studies.
  - All find increased RR locally for all-cause and cause specific, compared to national results.
  - 2013 all-cause RR not statistically significant, but similar magnitude; also cardiovascular RR positive and significant.
  - Use all-cause estimates from each (1.17, 1.17, 1.10).
- SCAQMD could consider sensitivity analysis with state and national level estimates.

# Results for Ozone Mortality

- Recommend including mortality due to short-term (daily) ozone exposure, based on 2008 NAS recommendation and adoption by USEPA. Focus on a pooled LA-specific estimate from two analyses reported in Bell et al., 2005.
  - LA result from multi-city NMMAPS analysis; and
  - Result from meta-analysis of multiple LA time series studies
  - Equal-weight pooling
- Reflects consideration of high quality meta-analyses and single or multi-city studies that included a specific estimate for Southern CA or LA.
  - Bell et al meta-analysis already includes other studies in our list (e.g., Kinney et al., 1995, Moolgavkar 2003)
  - Relatively tight confidence intervals compared to others
- Do not recommend including mortality associated with long-term exposures due to mixed results and concern about double-counting.

# New Endpoints

- Recommended:
  - Mortality (ozone, short-term)
  - Ischemic stroke, new incidence (PM)
  - Asthma, new incidence (ozone)
- Examples of endpoints evaluated but not recommended:
  - Pregnancy outcomes (e.g., low birth weight)
  - Autism
  - Diabetes
  - Neurological disorders (e.g., Parkinson's)

# Recommendations – Health Endpoints

| ENDPOINT | POLLUTANT | STUDY | STUDY POPULATION |
|---|---|---|---|
| **Premature Mortality** | | | |
| Premature mortality—all-cause, long-term exposure[a] | $PM_{2.5}$ (annual avg) | Pooled estimate of:<br>1. Jerrett et al. (2013) LA<br>2. Jerrett et al. (2005) LA<br>3. Krewski et al. (2009) LA | >30 years |
| Premature mortality—all-cause, short-term exposure | Ozone (24-hr avg) | Pooled estimate of:<br>1. Bell et al., 2005 (meta-analysis result for LA)<br>2. Bell et al., 2005 (NMMAPS result for LA) | All ages |
| Infant mortality—all-cause | $PM_{2.5}$ (annual avg) | Woodruff et al. (1997) | Infant (<1 year) |
| **Chronic Illness (new incidence)** | | | |
| Nonfatal myocardial infarction | $PM_{2.5}$ (24-hour avg) | Pope et al., 2006; Sullivan et al., 2005; Zanobetti et al., 2009; Zanobetti & Schwartz, 2006 | Adults (>18 years) |
| Stroke, Ischemic | $PM_{2.5}$ (24-hour avg) | Shin et al., 2014 | >65 years |
| Asthma incidence (new cases) | Ozone (8-hour max) | McConnell et al. (2010) | <18 years |
| **Hospital Admissions and ED Visits** | | | |
| Respiratory, all | $PM_{2.5}$ (24-hour avg) | Zanobetti et al, 2009, all respiratory | >65 years |
| | Ozone (8-hour max) | Katsouyanni et al. (2009) | 65-99 years |
| Respiratory | $PM_{2.5}$ (24-hour avg) | Moolgavkar (2000)—ICD 490-492, 494-496 (COPD, less asthma) | 18-64 years |
| Asthma-related Hospital Admissions | Ozone (8-hour max) | Moore et al. (2008) | <18 years |
| Asthma-related ED visits | Ozone (8-hour max) | Mar and Koenig (2009); Meng et al. (2009) | <18 years |
| Asthma-related ED visits and Hospital Admissions, combined | $PM_{2.5}$ (24-hour avg) | Delfino et al. 2014. | <18 years |
| Cardiovascular | $PM_{2.5}$ (24-hour avg) | Moolgavkar (2003)—ICD 390-429 (all cardiovascular) | >64 years |
| Cardiovascular | $PM_{2.5}$ (24-hour avg) | Moolgavkar (2000b)—ICD 390-429 (all cardiovascular) | 20-64 years |

# Recommendations – Health Endpoints (continued)

| ENDPOINT | POLLUTANT | STUDY | STUDY POPULATION |
|---|---|---|---|
| Other Health Endpoints (Not Requiring Hospitalization) | | | |
| Acute bronchitis | $PM_{2.5}$ (annual avg) | Dockery et al. (1996) | 8-12 years |
| Lower respiratory symptoms | $PM_{2.5}$ (24-hour avg) | Schwartz and Neas (2000) | 7-14 years |
| Upper respiratory symptoms | $PM_{2.5}$ (24-hour avg) | Pope et al. (1991) | 9-11 years |
| Asthma exacerbation | $PM_{2.5}$ (24-hour avg) | Pooled estimate:<br>Ostro et al. (2001) (cough, wheeze, shortness of breath)<br>Mar et al., 2004 (cough, shortness of breath) | 6-18 years |
| Asthma exacerbation | $PM_{2.5}$ (24-hour avg) | Young et al., 2014 | >34 years |
| | $NO_2$ (24-hour avg) | Pooled estimate:<br>O'Connor et al. (2008); Ostro et al. (2001); Schildcrout et al. (2006) | 4 - 12 years |
| Minor restricted-activity days /Acute respiratory symptoms | $PM_{2.5}$ (24-hour avg) | Ostro and Rothschild (1989) | 18-64 years |
| | Ozone (8-hour max) | Ostro and Rothschild (1989) | 18-64 years |
| | $NO_2$, $SO_2$ (24-hour avg) | Schwartz et al. (1994) | 7 - 14 years |
| Work loss days | $PM_{2.5}$ (24-hour avg) | Ostro (1987) | 18-64 years |
| School loss days | Ozone (8-hour max) | Gilliland et al. (2001) | 5-17 years |

# Conceptual Framework – Mortality and Morbidity Valuation

## Key Assumptions

- Individuals are best judge of their own welfare.
  - "Consumer sovereignty," respect individual preferences.
- Values based on individuals' willingness to exchange money for benefits ***they*** receive.

## Conceptual Framework

- Value per statistical case.
- WTP for own risk reductions.
- Revealed and stated preference methods.
- Use of benefit transfer.

## Value per Statistical Life (VSL)

- *Not the value of saving a specific individual's life with certainty.*
  - Those who would die in the absence of the intervention typically cannot be identified either *ex ante* or *ex post*.
- A ***statistical*** case is a sum of probabilities:
  - 1/10,000 risk change * 10,000 individuals
    = 1 statistical case.
- VSL conventionally calculated as individual WTP for a small annual risk change divided by the risk change.
- USEPA actively working on alternative terminology to minimize confusion.

# Conceptual Framework – Mortality Valuation

- Mortality - Approaches
  - Human Capital
  - Revealed Preferences
    - Averting Behavior
    - **Compensating Wage Differentials**
  - **Stated Preferences**

# Approach to VSL Review

- Literature review and "benefit transfer" approach
- Based largely on Robinson and Hammitt, 2015
  - Current, comprehensive VSL review
  - Stringent criteria derived from EPA SAB recommendations
  - Includes illness-based VSLs
- Supplemented with review 2014-present
  - Searched Scopus PubMed, EBSCO EconLit, Business, and Environment databases, Google Scholar
  - Included term for CA-specific estimates

# Criteria – Mortality Valuation

## CRITERIA FOR MORTALITY VALUATION STUDIES

| CRITERIA |
| --- |
| **GENERAL:** |
| 1. Study is written in English.<br>2. Study is publicly available.<br>3. Study is based on a sample of the general U.S. population. |
| **FOR REVEALED-PREFERENCE STUDIES:** |
| 4. Study uses hedonic methods that address the trade-off between wages and job-related risks.<br>5. Study relies on high-quality risk data, equal or superior to the Census of Fatal and Occupational Injuries (limits studies to those published from 2003 – present).<br>6. Study controls for potentially confounding factors, such as nonfatal injury risk as well as both industry and occupation. |
| **FOR STATED-PREFERENCE STUDIES:** |
| 7. Study elicits values for private risk reductions that accrue to the respondent.<br>8. Study expresses the risk change as a probability, not as a life extension.<br>9. Study estimates willingness-to-pay, not willingness-to-accept compensation.<br>10. Study provides evidence of validity, including sensitivity of willingness to pay to changes in risk magnitude (more likely to be met by studies published from 1994 – present). |

# Results of VSL Review

- Robinson and Hammitt, 2015
  - Most qualifying estimates based on wage-risk
    - $5.3 million to $13.7 million range; mid-point of $9.5 million
  - Three qualifying SP studies (two illness based):
    - $4.2 million to $11.2 million range; mid-point of $7.7 million
    - Results from illness studies similar to others
  - **Combined range $4.2 million to $13.7 million; mid-point of $9.0 million**
- No evidence of CA-specific estimates
- Supplemental review found no newer studies that met criteria

# Recommendations - VSL

- Recommended Value (2013 dollars and income levels)
  - Central VSL estimate = **$9.0 million**.
  - Range = **$4.2 million** to **$13.7 million**.
- Represents increase over VSL in 2012 analysis
  - Previous VSL $7.1 million to $7.8 million, inflated to 2013 dollars (not income adjusted)
  - Previous values encompassed in our range; will be reflected in uncertainty analysis
  - Based on current, highest quality, best practice studies identified by expert endorsed criteria for revealed and stated preference studies

# Recommendations – Adjustments to VSL

- Adjustment for Inflation to dollar year of study
- Real income growth over time (elasticity=1.1)
  - Based on central estimate of Viscusi (2015) meta-analysis
  - Combines results from several studies that attempt to control for publication bias
  - SCAQMD could consider sensitivity analysis using a range of 0.0 to 1.4 based on other recent studies
- Discount for latency (cessation lag)
  - Use EPA SAB's recommended 20 year lag step function for primary estimate
  - Conduct sensitivity analysis (pick two):
    - zero-year lag
    - 2012 PM NAAQS model (shift to longer latency risks)
    - 5-year distributed lag (25/25/17/17/17)
    - Exponential smooth function (k=0.45 from PM NAAQS RIA)

# Criteria – Morbidity Valuation

## CRITERIA FOR MORBIDITY VALUATION STUDIES

| CRITERIA |
| --- |
| **GENERAL:** |
| 1. Study is publicly available.<br>2. Study is written in English.<br>3. Study is conducted in the U.S. |
| **FOR STATED-PREFERENCE STUDIES:** |
| 4. Study elicits values for private risk reductions that accrue to the respondent.<br>5. Study estimates WTP, not WTA compensation. |
| **FOR COI STUDIES:** |
| 6. Study includes clear description of the elements that make up the COI estimate.<br>7. Study includes clear description of health endpoint and estimates incidence-based or prevalence-based cost as appropriate for the health endpoint evaluated.<br>8. Prefer studies that estimate costs specific to affected groups (especially, affected age groups). |

# Morbidity Valuation Results

- Lack of high-quality, relevant WTP studies remains an issue
  - WTP estimates for respiratory ailments
  - "partial" WTP for hospital admissions
  - COI-based estimates for all others
- Updated COI-based estimates where appropriate
  - Recent CA HCUP data for HAs
  - Updated estimates of lost time based on CA wage data
  - Local 2012 asthma study; 4-year stroke cost
- COI estimates likely underestimate true value of health effects. Consider augmenting stroke value for indirect costs, in particular.
- Adjustments for 2016 analysis
  - Inflate costs to appropriate dollar year
  - Adjust WTP estimates for income growth
  - Apply consistent discount rate for multi-year impacts

# Recommendations– Morbidity Valuation

| NONFATAL ENDPOINT[A] (AGE RANGE) | POLLUTANT | VALUATION ESTIMATE[B] | VALUATION METHOD |
|---|---|---|---|
| **New incidence (chronic)** | | | |
| Ischemic stroke: hospital admissions (>65 years) | PM | $61,384 (Lee et al. 2007) | COI (medical costs) |
| Myocardial infarction: hospital admissions (>18 years) | PM | $106,293 to $223,214 depending on age (Cropper and Krupnick 1990, Russell et al. 1998, Wittels et al. 1990) | COI (direct and indirect) |
| Asthma (<18 years) | Ozone | $48,066 (13-year NPV based on annual costs in Brandt et al. 2012) | COI (direct and indirect) |
| **Hospitalization and emergency room visits only** | | | |
| Cardiovascular disease: hospital admissions (>20 years) | PM | $23,469 (HCUP, Chestnut et al. 2006) | COI (direct and indirect) |
| Respiratory disease: hospital admissions (>18 years) | PM, Ozone | $21,509 (HCUP, Chestnut et al. 2006) | COI (direct and indirect ) |
| Asthma-related emergency room visits and hospital admissions (<18 years) | PM, Ozone | $9,131 (hospital admissions: HCUP, Chestnut et al, 2006) $425 - $623 (emergency visits: Smith et al., 1997, Stanford et al., 1999, Meng et al, 2010) | COI (direct and indirect) |

Notes:

a. Endpoints are from IEc's September 23, 2015 and October 2, 2015 memoranda. Age ranges encompass all PM and ozone-related studies; individual studies generally address a narrower range.
b. All values are per statistical case unless otherwise noted.
c. As discussed earlier, three meta-analyses support values within this range, although each includes studies that are not consistent with our evaluation criteria (Johnson et al. 1997, Vassanadumrongdee et al. 2004, Van Houtven et al. 2006).

# Recommendations– Morbidity Valuation

| NONFATAL ENDPOINT[A] (AGE RANGE) | POLLUTANT | VALUATION ESTIMATE[B] | VALUATION METHOD |
|---|---|---|---|
| **Other respiratory ailments (not requiring hospitalization)** | | | |
| Acute bronchitis (8-12 years) | PM, Ozone | $17 to $294 per day (Brandt et al. 2012, Dickie and Messman 2004)[C] | WTP |
| Lower respiratory symptom-days (two or more of the following: cough, chest pain, phlegm, wheeze)(7-14 years) | PM, Ozone | | WTP |
| Upper respiratory symptom-days (runny or stuffy nose, wet cough, burning, aching, or red eyes)(9-11 years) | PM, Ozone | | WTP |
| Acute respiratory symptoms-days (hoarseness, sore throat, cough, phlegm)(7-14 years) | Ozone | | WTP |
| Asthma exacerbation symptom-day (cough, wheeze, shortness of breath, tightness of chest)(4-18 years, >34 years) | PM, Ozone | | WTP |
| **Activity restrictions** | | | |
| Work loss days (18-64 years) | PM | $217 per day (BLS 2012) | COI (compensation only) |
| School loss days (5-17 years) | Ozone | $217 per day (BLS 2012) | COI (parent's lost time only) |
| Minor restricted-activity days (not resulting in work loss or bed disability)(18-65 years) | PM, Ozone | $17 to $294 per day (Brandt et al. 2012, Dickie and Messman 2004)[C] | WTP |

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a. Endpoints are from IEc's September 23, 2015 and October 2, 2015 memoranda. Age ranges encompass all PM and ozone-related studies; individual studies generally address a narrower range.
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c. As discussed earlier, three meta-analyses support values within this range, although each includes studies that are not consistent with our evaluation criteria (Johnson et al. 1997, Vassanadumrongdee et al. 2004, Van Houtven et al. 2006).


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