Environmental Benefits Mapping and Analysis Program

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Overview

• What is a human health benefits analysis and what purpose does it serve?
• How can BenMAP help perform a benefits analysis?
• Data inputs to BenMAP
• Demonstration of model interface and outputs
• Analytical transparency in BenMAP
• Use of BenMAP in non-US projects
What is a Human Health Benefits Analysis?

• The process of:
  • estimating of improvements in health outcomes that result from improvements in air quality
  • applying a monetary value to those improvements in health outcomes
  • Benefits information can help inform the selection of optimal air regulations
Benefits Analysis

Baseline conditions
(air quality WITHOUT
regulation/policy scenario
in place)

Control conditions
(air quality WITH
regulation/policy scenario in
place)

Change in air quality (difference
between baseline and control air quality
conditions)

Reduction in population-level
exposure to air pollution

Reduction in health effects
incidence
(deaths and disease cases)

Monetary value (benefits) of
health effects incidence
reductions

Regulatory / policy
scenario
What Health Effects Does EPA Quantify?

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<tr>
<th>Current</th>
<th>Particulate Matter</th>
<th>Ozone</th>
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<td>(✓)</td>
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<td></td>
</tr>
<tr>
<td>Nonfatal heart attacks</td>
<td>✓</td>
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<tr>
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<td>Worker productivity</td>
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<tr>
<td>School absence rates</td>
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Benefits Analysis

Baseline conditions (air quality WITHOUT regulation/policy scenario in place)

Change in air quality (difference between baseline and control air quality conditions)

Reduction in population-level exposure to air pollution

Reduction in health effects incidence (deaths and disease cases)

Monetary value (benefits) of health effects incidence reductions
How Do You “Value” Changes in Health Outcomes?

- Cost of Illness (COI)
  - Medical expenses for treatment of illness
  - Captures the money savings to society of reducing a health effect
  - Ignores the value of reduced pain and suffering

- Willingness To Pay (WTP)
  - Lost wages, avoided pain and suffering, loss of satisfaction, loss of leisure time, etc.
  - Measures the complete value of avoiding a health outcome
The BenMAP Model

A geographic information system-based program that:

- creates population level exposure surfaces
- estimates changes in incidence of a variety of health outcomes associated with changes in certain ambient air pollutants
- places a dollar value on changes in incidence of health outcomes
The Data BenMAP Uses to Perform a Benefits Analysis

BenMAP Input

US Census Data

Population Estimates

Population Projections

Air Quality Modeling

Population Exposure Projections

Air Quality Monitoring

Health Functions

Adverse Health Effects

Baseline & Projected Incidence Rates

Economic Benefits

Valuation Functions

User Input Choice

Result from Inputs
Key Features of BenMAP

• User-friendly experience
  • Driven by windows-based graphical user interface
  • Results (exposure, incidence, and valuation) available in a variety of formats including ASCII, .dbf, and shape files

• Comprehensiveness
  • Model includes a substantial population, health and air quality databases
  • Model incorporates an integrated GIS mapping, query, and statistics tool

• Flexibility
  • Enables users to perform a standardized or highly customized analysis
  • Users can add their own population, air quality, and health databases
Options for Providing BenMAP with Air Quality Data

• Model accepts user-provided air quality data, both monitored and modeled

• Provides several options for creating population exposure maps:
  • direct use of monitor or model data
  • use of model data with monitor data in a relative sense
Options for Specifying Benefits Analysis

• Preloaded with hundreds of PM and Ozone concentration-response functions from US and Canadian studies

• Users can easily add more C-R functions with the equation editor

• Users can add region-specific baseline incidence rates

• Model enables users to pool and aggregate incidence and valuation results

• Model estimates distributions of incidence and valuation results using Monte Carlo methods
The BenMAP Interface

Data Entry and Utilities

Program Function Buttons
Alternative Ways to Analyze Air Quality Data

• Monitor Rollbacks

  • Useful for answering hypothetical questions like: “What if PM2.5 levels were reduced by 20 percent in Mexico City?”

  • Available options include percentage reduction, absolute reduction, and rollback to standard

• Spatial and Temporal Scaling

  • Use a combination of modeling and monitoring data to project future air quality

• Monitor Direct

  • Import monitoring data into BenMAP
Step Two: Estimating Health Impacts
Step Three: Pooling, Aggregating, and Valuing Health Impacts
Step Four: Reporting Results

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<tr>
<th>Column</th>
<th>Row</th>
<th>Endpoint Group</th>
<th>Qualifier</th>
<th>Point Estimate</th>
<th>Population</th>
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Examples of Graphs Produced Using BenMAP Outputs (1) Age Group Impacts

Mortality Impacts by Age Group

- 30 to 34
- 35 to 44
- 45 to 54
- 55 to 64
- 65 to 74
- 75 to 84
- 85 and Up
Examples of Graphs Produced Using BenMAP Outputs
(2) Distributions of Incidence

Cumulative Distribution of Total Change in Mortality from a 30% Reduction in PM$_{2.5}$ Levels

Mean Reduction = 42,366
Examples of Graphs Produced Using BenMAP Outputs

(3) Distributions of Monetized Benefits

Cumulative Distribution of Value of Reductions in Premature Mortality from a 30% Reduction in PM2.5 Levels
Map underlying population, air quality, and incidence rates
Analytical Transparency and Reproducibility

• BenMAP designed for public use and public scrutiny

• Published a detailed User’s Guide with extensive appendices documenting model algorithms and data sources

• With each run, the user can generate an “audit trail” listing details of the run for QA and comparison with other analyses

• Consistent with Data Quality Guidelines, this “audit trail” can and should be shared with reviewers
Example International BenMAP Projects

- South Korea: Health benefits of Seoul air quality management plan
- Latin America: Benefits of air quality improvements in Mexico City, São Paulo, Santiago
- India: Benefits analyses in Mumbai and Pune of alternate air quality policies
Using BenMAP International

• Program components users must modify:
  • Baseline and projected population data
  • Monitoring data (if applicable)
  • Valuation function library

• BenMAP components users should consider modifying:
  • Concentration-response function library
  • Baseline and projected incidence rates
  • Income growth adjustment functions
Derivation of Effects Estimates

\[ \ln(y) = \ln(B) + \beta(PM) \]

\[ \Delta Y = Yo (1 - e^{-\beta \Delta PM}) \]

\( \beta \) - Effect estimate

\( Yo \) - Baseline Incidence

Epidemiology studies – derivation of concentration-response functions (beta values)
Valuation Procedures (I)

- WTP reflects individuals' preferences
- Market goods - e.g., buying a new automobile
- Non-market goods - e.g., health-related improvements in environmental quality
- WTP for a non-market good difficult to estimate
- Decrease the risk of a day of coughing
- Decrease the risk of admission to the hospital for respiratory illness
- Benefits analysis estimates the value of a statistical health problem avoided
- Reduction in air pollutant concentrations results in a reduction in mortality risk
Valuation Procedures (II)

• EXAMPLE: Value of a *statistical* life saved

• 1 µg/m³ reduction in pollutant concentration produces decrease in mortality risk of 1/10,000

• For every 10,000 individuals, one individual would be expected to die in the absence of the reduction in PM concentrations

• WTP for this 1/10,000 decrease in mortality risk is $500

• Value of a *statistical* life is 10,000 x $500 = $5 million

• *International benefits transfer* between countries