What tools/models are available to assess the health risks of air pollution at various scales (local, national, regional, global)?

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Disclaimer: Views expressed in this presentation are mine and do not necessarily represent the views or policies of the U.S. EPA.

Introduction

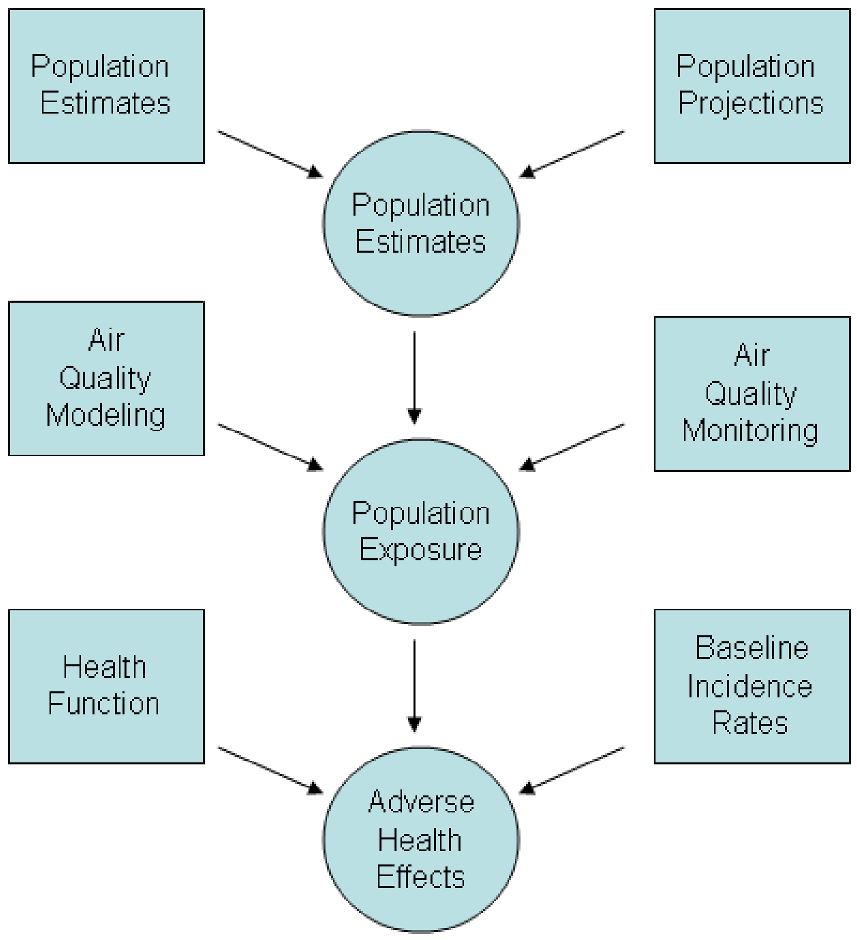
- Recent advances in air pollution epidemiology and exposure science enable quantitative air pollution health impact assessment at various spatial scales and resolutions for several pollutants
- Using computer programs to automate the procedure offers several advances:
  - Simplicity (lowering the barrier of entry for new analysts to conduct assessments)
  - Consistency
  - Comparability among assessments
  - Quality assurance
- The available tools vary in key technical and operational characteristics
  - Technical: spatial resolution, pollutants and health effect outcomes evaluated, and method for characterizing population exposure
  - Operational: tool format, accessibility, complexity, and degree of peer-review and application in policy contexts
- This discussion focuses on ambient air pollution because tools for quantifying household air pollution health impacts are in an earlier stage of development

Available tools

- Tools with global extent
  - AirCounts^{TM} – Abt Associates
  - AirQ2.2 – WHO
  - BenMAP-CE – U.S. EPA
  - Environmental Burden of Disease (EBD) – WHO
  - GMAPS – World Bank
  - IOMLIFET – Institute of Occupational Medicine
  - Rapid Co-benefits Calculator – U.S. EPA, Stockholm Environment Institute, Univ of Colorado
  - SIM-Air – Urban Emissions
  - TM5-FASST – Joint Research Centre of the European Commission
- Tools with regional extent
  - Aphekom – French Institute of Public Health Surveillance
  - EcoSense – University of Stuttgart
  - Economic Valuation of Air pollution (EVA) – Aarhus University
- Additional tools with national extent: AQBAT (Canada), AP2 (U.S.), COBRA (U.S.), ICAP (Canada), ITHIM (UK)

General principles: pollutants and health effect outcomes

- All tools combine population, baseline disease/mortality rates, and “exposure” estimates with epidemiologically-derived “exposure”-response relationships
- All but one tool reviewed assess $PM_{2.5}$ impacts
  - 8 assess PM_{10} impacts
  - 2 include only primary $PM_{2.5}$
  - 8 assess ozone
  - 5 assess additional pollutants (NO_2, SO_2, etc.)
- All assess impacts on mortality, and many also estimate morbidity, DALYs, and YLL
- Most estimate health impacts attributable to air pollution in a single year, though the impacts may lag over a multi-year period



General principles: Resolution and exposure characterization

Exposure information source	User Input	Global scope	Regional scope
Any concentration input by user	Concentration	BenMAP-CE AirQ2.2 IOMLIFET	EBD
In situ monitor	Concentration		Aphekom
Global chemical transport model (input by user)	Concentration		EVA
Regional or urban atmospheric chemistry model (input by user)	Emissions	SIM-Air	
Reduced-form global chemical transport model	Emissions	Co-benefits Calculator TM5-FASST	EcoSense
Reduced-form econometric model	Economic and climate indicators	GMAPS	
Intake fraction (primary $PM_{2.5}$ only) [5]	Emissions	AirCounts™	

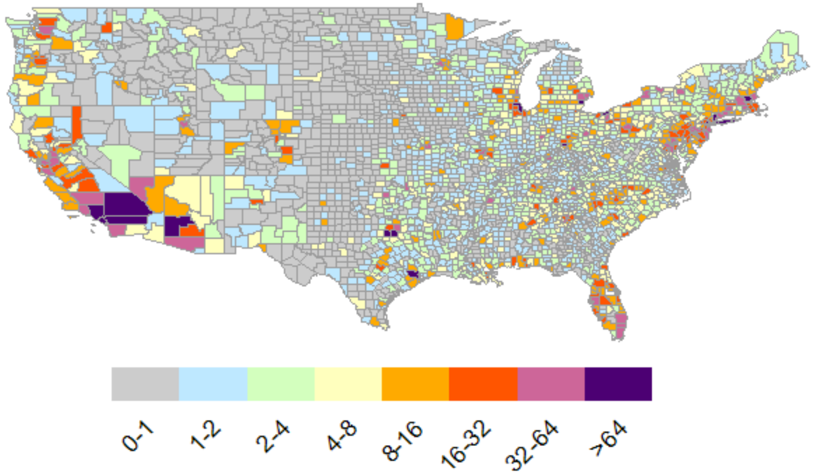
General principles: Resolution and exposure characterization

- All tools except for two use some form of air quality modeling to estimate exposure
  - Full scale – gridded assessments reading in air quality information simulated externally
  - Reduced form – using built-in relationships between emissions and the exposure metric derived from externally conducted air quality model simulations
- The remaining two tools use monitoring or economic modeling (i.e. using economic indicators to predict concentrations)
- Some tools can use either modeling or monitoring (e.g. BenMAP-CE)
- Range of exposure characterization methods represents an important trade-off between technical refinement and accessibility for a broad range of applications
  - Some applications require technically rigorous, highly refined analyses
  - Air quality modeling is often unavailable or impossible, and less refined tools can be used to fill in information gaps
  - Even in areas where more refined analyses are possible, reduced form tools allow one to screen many scenarios to identify those that should be examined in more detail

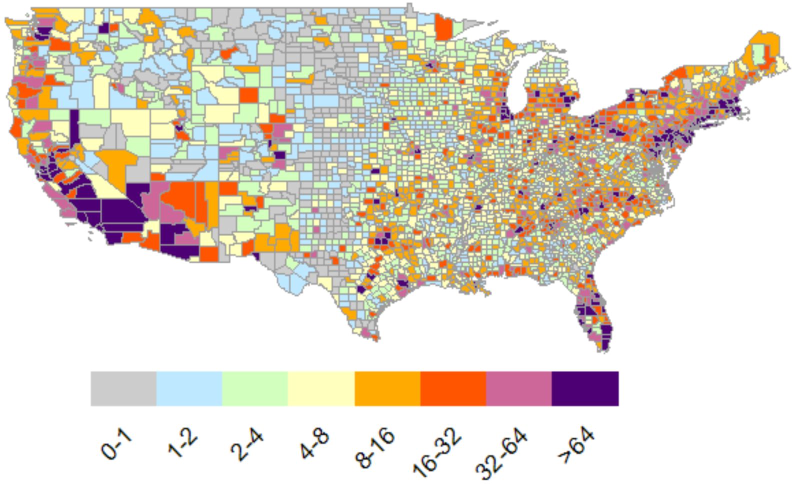
Case study 1: U.S. National Ambient Air Quality Standard for Ozone 2nd draft Risk and Exposure Assessment

- National mortality burden due to **short-term** ozone exposure in 2007:
  - Estimated 15,000 (95% confidence interval, 1,400-28,000) premature ozone-related non-accidental deaths
  - Short-term ozone-attributable deaths correspond to 0.4%-0.7% of total mortality across U.S. counties (median 0.6%)
- National mortality burden due to **long-term** ozone exposure in 2007:
  - Estimated 45,000 (17,000-70,000) premature ozone-related deaths due to respiratory disease
  - Long-term ozone-attributable deaths correspond to 1.3%-2.6% of total mortality across U.S. counties (median 1.9%)

County-level premature deaths due to **short-term** ozone exposure

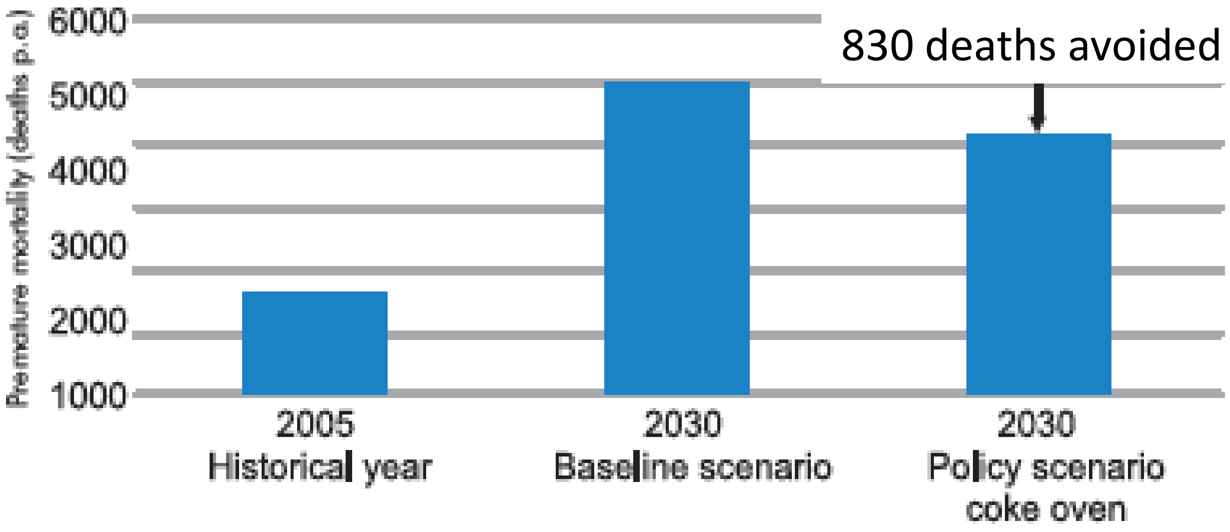


County-level premature deaths due to **long-term** ozone exposure



Case study 2: Short-lived Climate Pollutant National Action Planning under the Climate and Clean Air Coalition

Projected black carbon emissions for 2030, calculated by LEAP-SLCP, reduced from 22,000 to 1,600 tonnes by assuming complete implementation of modern coke ovens in Colombia. Premature mortality reduced by 830 people each year from reduced $PM_{2.5}$ concentrations, as calculated by the benefits calculator.

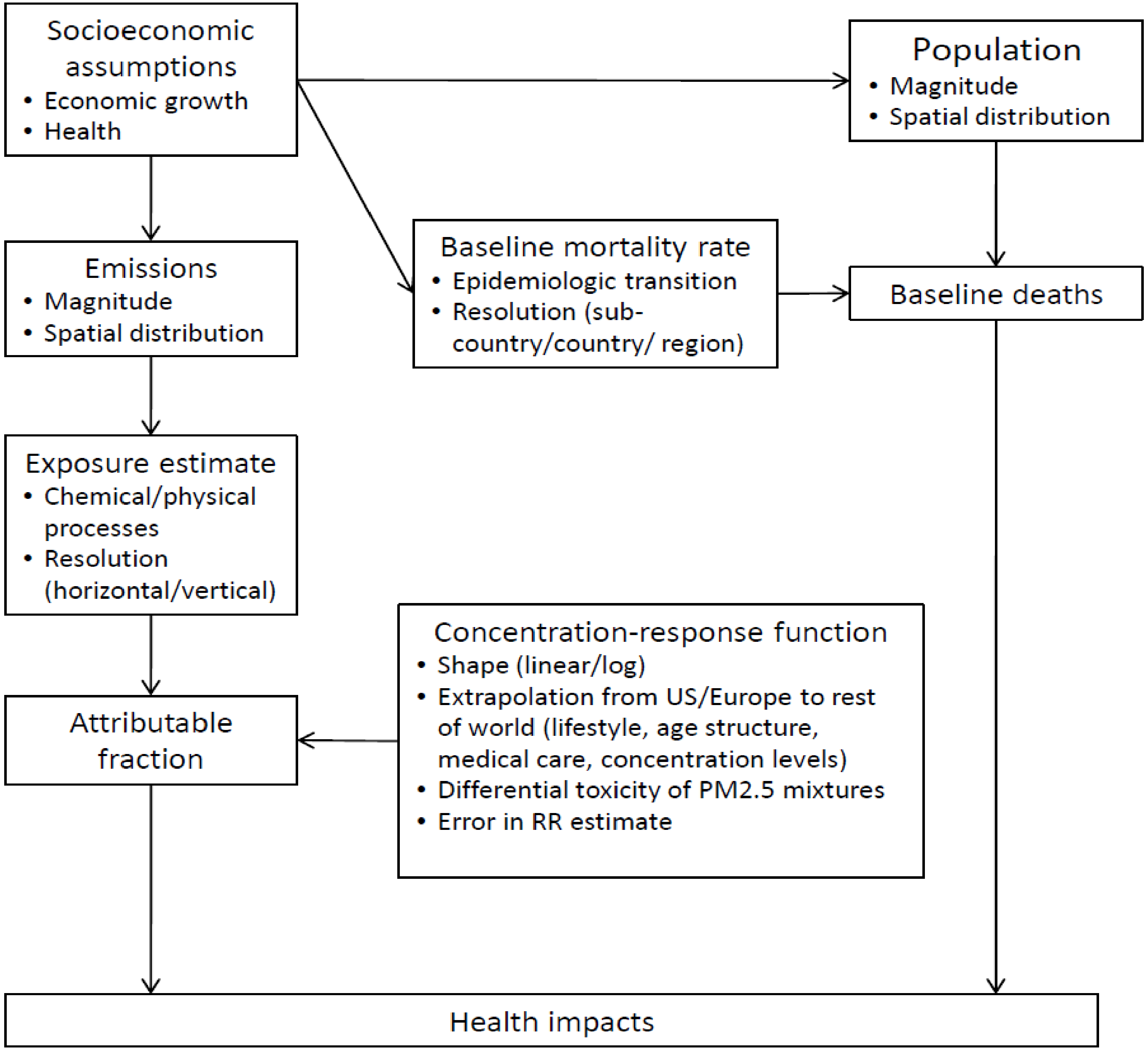


General principles: Key operational characteristics

- Mix of tool format:
  - 3 client-based software programs
  - 7 programs that run within Microsoft office
  - 2 web-based (+2 in preparation)
- Range of technical complexity and accessibility
- Most tools have been peer-reviewed, range in degree of application in policy contexts
- Most are maintained as a “living” tool (updating population, baseline disease rates, emissions, operating systems)

Uncertainties

- Concentration-response function
- Exposure
- Projecting future emissions, population, and disease rates



Future needs

- Develop guidance to help analysts match the abilities of individual tools with specific assessment contexts
  - Choose policy questions, pollutants, scale, and then tool that will satisfy
  - Consider who is asking the question versus who will take action
  - Recommendation: a small group should continue working on this, developing it in the form of a decision tree, and thinking about commonalities and harmonization of methods
- Develop guidance for interpreting and communicating results
- Better account for multiple sources of uncertainty
- Integrate with tools addressing household air pollution and other health factors, such as vehicle accidents and physical activity. Examples:
  - Household Air Pollution Impacts Tool (HAPIT)
  - International Futures
  - Integrated Transport and Health Impact Modeling Tool (ITHIM)
  - Lives Saved Tool (LiST)
  - Health Economic Assessment Tool

Extra slides

Global tools: technical characteristics

Characteristic	AirCounts™	AIRQ2.2	BenMAP-CE	Co-benefits Calculator	EBD	GMAPS	IOMLIFET	SIM-Air	TM5-FASST
Spatial resolution:									
Regional		x	x		x		x	x	x
National		x	x	x	x	x	x		x
City-level	x	x	x			x	x	x	
Any grid		x	x				x		
Pollutants:									
$PM_{2.5}$	x (primary)	x	x	x	x		x	x[1]	x
PM_{10}		x			x	x	x	x	
Ozone		x	x	x			x		x
NO_2		x	x						x
SO_2		x	x						x
CO			x						
Other		Black smoke					Any affecting mortality		
Health outcome:									
Mortality (cases)	x	x	x	x	x	x	x	x	x
Disability-adjusted life years (DALY) or years of life lost (YLL)		x	x		x	x	x		x
Morbidity (cases)		x	x		x		x	x	

Global tools: operational characteristics

Characteristic	AirCounts™	AIRQ2.2	BenMAP-CE	Co-benefits Calculator	EBD	GMAPS	IOMLIFET	SIM-Air	TM5-FASST
Format:									
Software download		x	x						
Microsoft office program				x	x	x	x	x	x
Web-based	x			In prep					In prep
Open-source		x	x	x	x	x	x	x	In prep
Proprietary	x								x
Peer reviewed/policy applications:									
Peer-reviewed	In prep	Expert	x	In prep	x	In prep	x	x	In prep
Used for policy applications		x	x	x		x	x	x	x

Regional tools: technical characteristics

Characteristic	Aphekom	EVA	EcoSense
Region	Europe	Northern Hemisphere	Europe
National		x	x
City-level	x	x	x
Grid		x	x
Pollutants:			
$PM_{2.5}$	x	x	x (primary)
PM_{10}	x	x	x
Ozone	x	x	x
NO_2		x	x
SO_2		x	x
CO		x	
Other		Dioxins, mercury, black carbon	Heavy metals
Health outcome:			
Mortality (cases)	x	x	x
Disability-adjusted life years (DALY) or years of life lost (YLL)	x	x	x
Morbidity (cases)	x	x	x

Regional tools: operational characteristics

Characteristic	Aphekom	EVA	EcoSense
Format:			
Software download		x	
Microsoft office program	x		
Web-based			x
Open-source	x		
Proprietary		x	x
Peer reviewed/policy applications:			
Peer-reviewed	x	x	
Used for policy applications	x	x	x