What are the major ways that transportation systems influence public health?
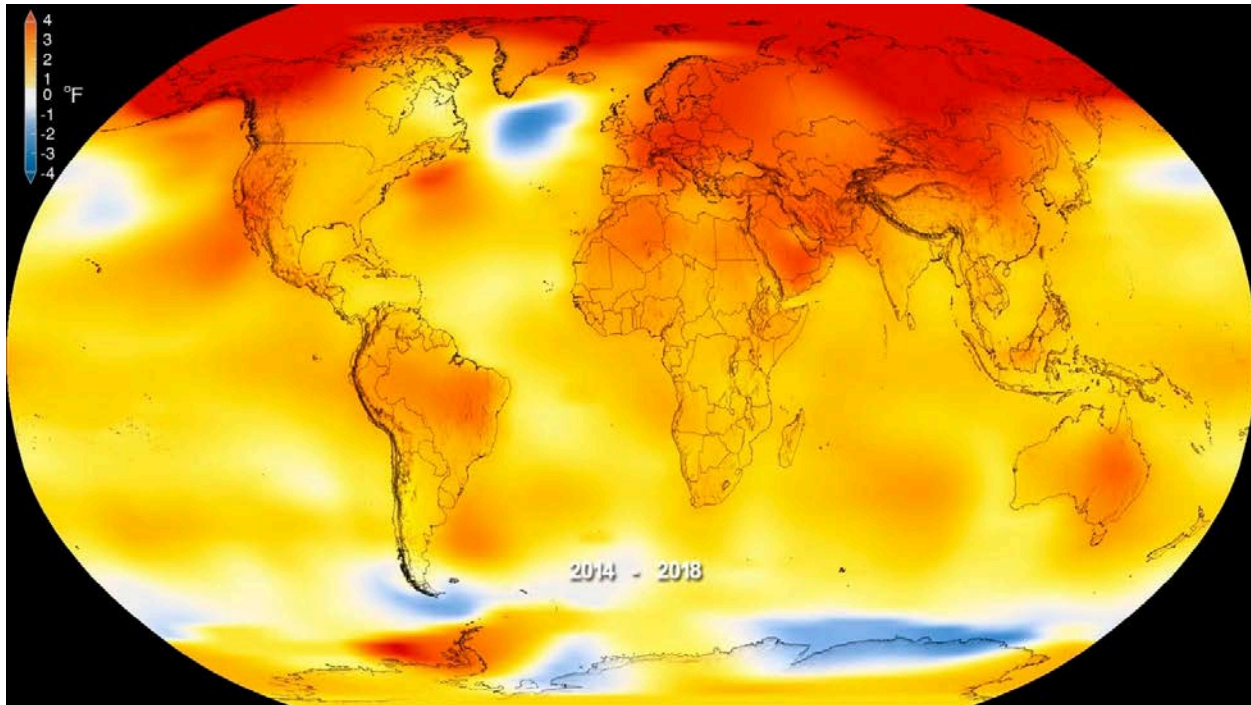
Health Implications of Transportation Systems

Effects	Description	Urban	Rural
Climate change	Temp, precip, extreme events, direct & indirect effects	Social cost $40/ton CO2e*	Social cost $40/ton CO2e*
Air pollution	Local emissions and regional transport	11.2 days > PM2.5 standard*	0.95 days*
Noise	Largest source of noise in most communities	35-90 db* (24-hr ave)	0-55 dB*(24-hr ave)
Traffic injury/fatalities	Vehicular, cyclist, pedestrian	Fatality rates 0.79 per 100M VMT	1.96 per 100M VMT
Physical Activity	Promote or hinder walking, cycling	Share walking 15-30% Share biking 2%	Share walking 8% Share biking 0.5%
Social effects	Promote or hinder access to jobs, healthcare, education, etc	Average distance to hospital 4.4 miles*	Average distance to hospital 10 miles*

On-Road Vehicle Emissions
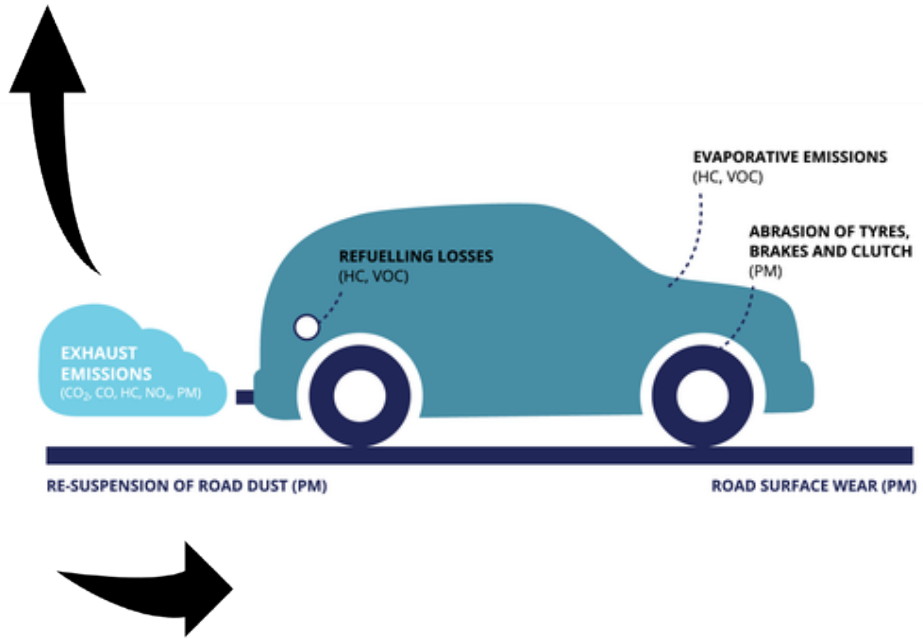
Distance to Roads Matters

Smith 2013
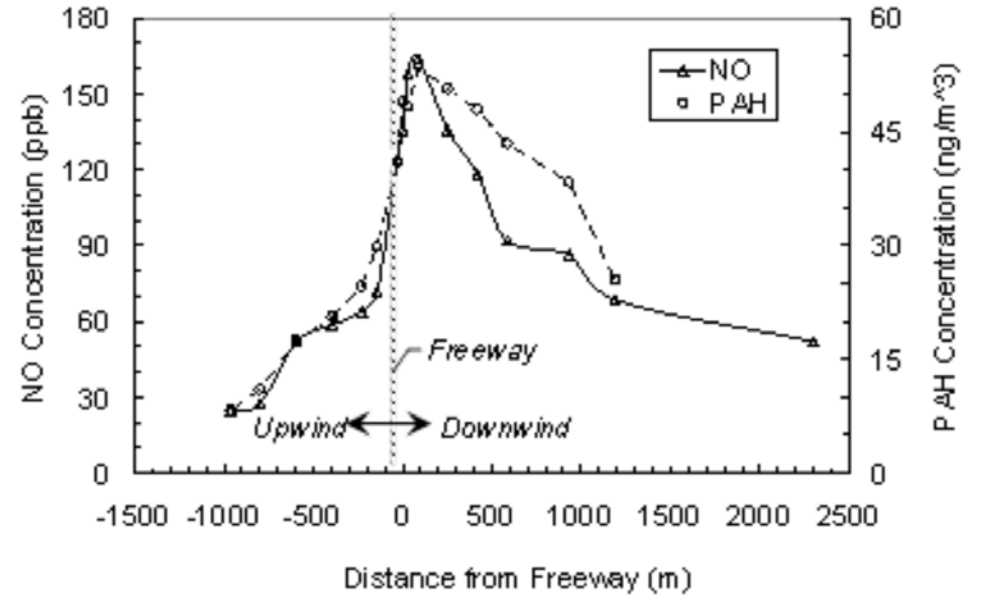
Estimated Health & Climate Effects – Passenger Vehicles, 2015

Estimated Health and Climate Costs, 2015 (billion$)

State	Cost (billion$)
CT	1.4
ME	0.5
MD	2.6
MA	2.9
NJ	4.6
NY	7.9
RI	0.4
VT	0.3
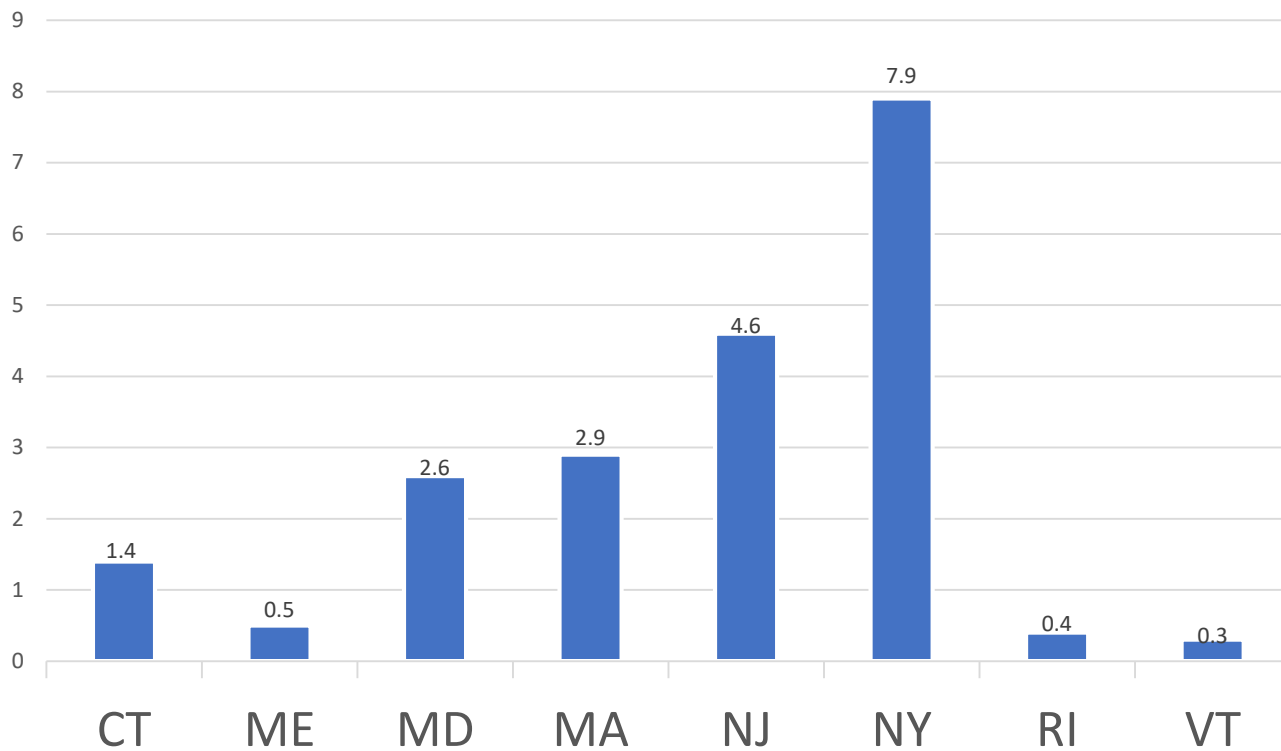
Health Effect	Cases
Premature Mortality	1,316
ER Visits, Respiratory	466
Acute Bronchitis	1,294
Respiratory Symptoms	705,668
Work Loss Days	112,347
Asthma Exacerbation	109,637
Heart Attack	967
Hospitalizations: Respir. & Cardio	488

Active Transportation

- Modes: biking, walking trips, walking to and from transit

- Increase of 30 minutes of physical activity reduces risk:
    - Heart disease, obesity, diabetes 50%
    - Hypertension 30%

- Risks: traffic injury, air pollution exposure, crime
- On-balance: positive

WHO 2011, Office of the Surgeon General 2015

How could different strategies for investing program proceeds affect health outcomes?

Comparison of Transportation Benefits
IPCC Mitigation Measures

Effects	Land use and alternatives to private motorized transport	Pricing policies (vehicle & fuel use, congestion)	Modified vehicles & fuels
Air pollution	++	- to ++	- to ++
Noise	++	0 to ++	0
Traffic injury/fatality	++	0 to ++	0
Physical activity	++	0 to ++	0
Social effects	++	0 to ++	0

WHO 2011, Fulton 2005, Barias et al. 2005

Estimated Transportation Mitigation Benefits - TCI Region

Measure	Benefits in 2030	Monetized value
Climate	12-72 mmt GHG avoided	$480-2880
Air pollution	19 deaths prevented	$152
Traffic injuries/fatalities	166 fatalities prevented	$1494
Physical activity	**420 deaths prevented**	**$2941**
Pavement damage	Avoided maintenance costs	$408

Adapted from Cambridge Systematics 2015

Benefits of Access to Public Transit

Effect	Benefits of retaining 53-64 million trips on public transit	Monetized value (annual; millions)
Air pollution	Avoid 0.26 additional deaths/yr Avoid 0.24 additional/yr hospitalizations	$2.1
Noise	Avoid exposure of 2000 people to increase of 60dB of noise on average per day	-
Traffic injury/fatalities	Avoid 1.15 new deaths/yr	$48.8
Physical Activity	Avoid 14 additional deaths/yr	$116.5
Social effects	2200 public transportation-dependent households retain access to healthcare resources	-

James et al. 2014

Summary

1. Transportation has large health effects that disproportionately affect low income and communities of color.

2. Climate change mitigation for transportation has the potential to generate substantial public health benefits and help alleviate current inequities.

3. Regional differences exist in transportation related health effects urban residents experience greater air and noise pollution, rural residents depend vehicle use for access to distant services and experience less active transport.

4. Existing research suggests that investments that promote compact mixed use development, increase use of active & public transport, and discourage travel in private motor vehicles would provide larger health benefits than policies focused solely on lower-emission motor vehicles.

What can modeling tell us about the distribution of costs and benefits under different regional policy design decisions?

Proposed Air Quality & Physical Activity Modeling

Approach

- Multi-model approach to estimate health effects of changes in emissions of criterion pollutants from on-road sources and changes in active transport.
- Multiple pollutants (not just PM)
- Spatially explicit results (maps)
- Allocates changes to sources (source categories and states)

Phase 1

- Quick, coarse estimates of health benefits of just $PM_{2.5}$ changes
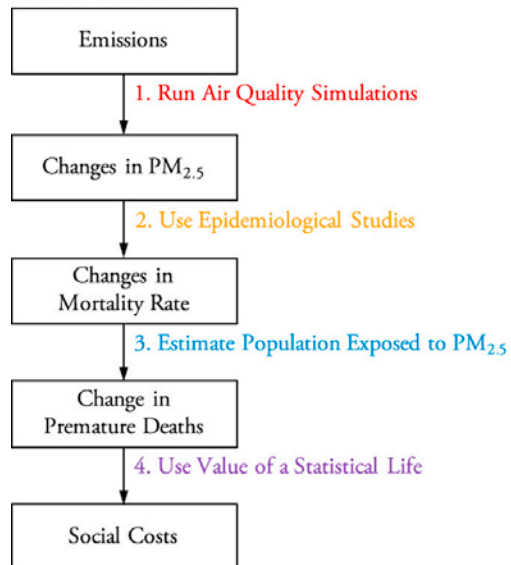- Regional assessment of active transport benefits

Phase 2

- County level health benefits including both $PM_{2.5}$ and ozone, and impacts of volatile organic compound (VOC) emissions
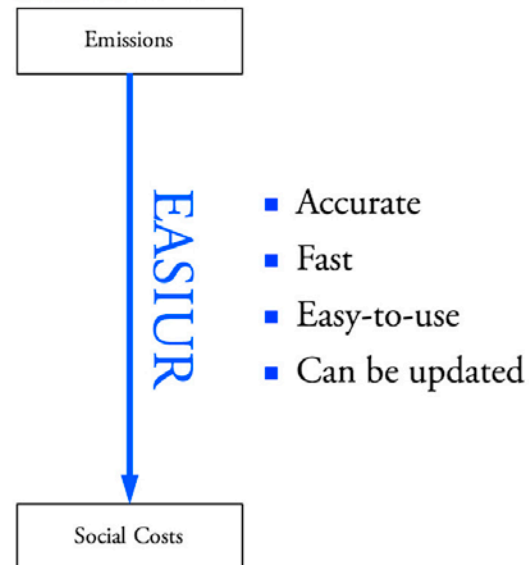- Analysis of equity (distributional) effects

Phase 1: Air Quality - EASIUR/ASPCA

The Estimating Air pollution Social Impact Using Regression (EASIUR) Model

Standard Method

Emissions

↓ *1. Run Air Quality Simulations*

Changes in $PM_{2.5}$

↓ *2. Use Epidemiological Studies*

Changes in Mortality Rate

↓ *3. Estimate Population Exposed to $PM_{2.5}$*

Change in Premature Deaths

↓ *4. Use Value of a Statistical Life*

Social Costs

EASIUR Method

Emissions

↓ EASIUR

Social Costs

- Accurate
- Fast
- Easy-to-use
- Can be updated

- Simplified model to estimate total health benefits of reduced emissions for $PM_{2.5}$, in $ terms

- Models $ benefits across the region of reducing emissions of $PM_{2.5}$ in a location

- Can also model benefits in a given location of reducing emissions elsewhere

Heo et al. 2016, 2017
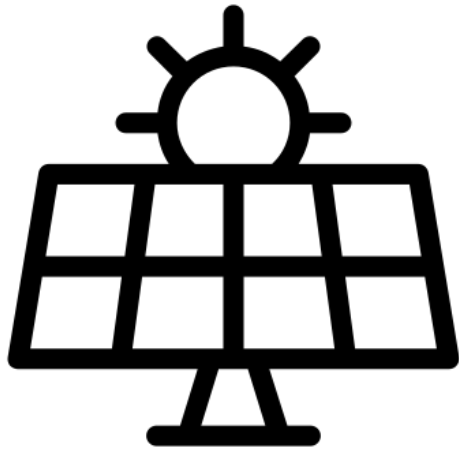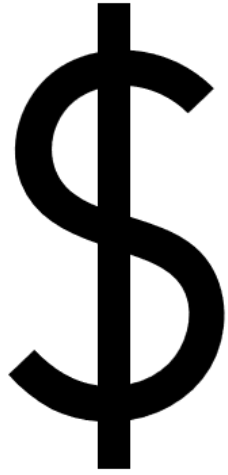
EASIUR/ASPCA – Sample Output

- There is $86 billion in health damages due to $PM_{2.5}$ in New York City, and $26 billion in Washington, DC

- The health benefits of renewable energy are the highest if they are deployed in the Upper Midwest

Phase 2: CMAQ-DDM & BenMap

- County level health benefits of TCI scenarios
- 12 km x 12 km resolution air quality results
- Model details
  - Community Multi-Scale Air Quality Model (CMAQ) version 5.1 – a state-of-the-science air quality model, commonly used by the EPA and others to evaluate policies
    - New chemistry to include the impacts of volatile organic compounds (VOCs)
  - DDM – direct-decoupled method –tracks transport of air pollution, and can be used to quickly evaluate policy scenarios

CMAQ DDM – Example
## Air pollution "footprints" from residential fuel use in CA and OR
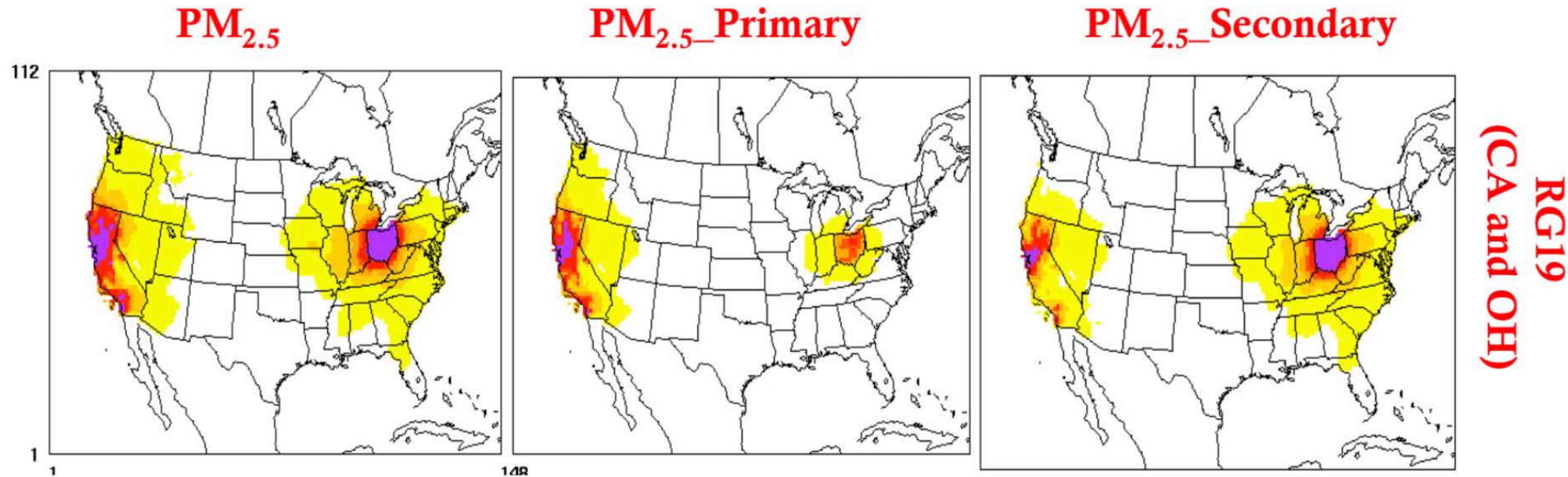
- Shows how emissions in one location affect air pollution downwind
- Can different policy scenarios quickly, without re-running the air pollution model for each scenario
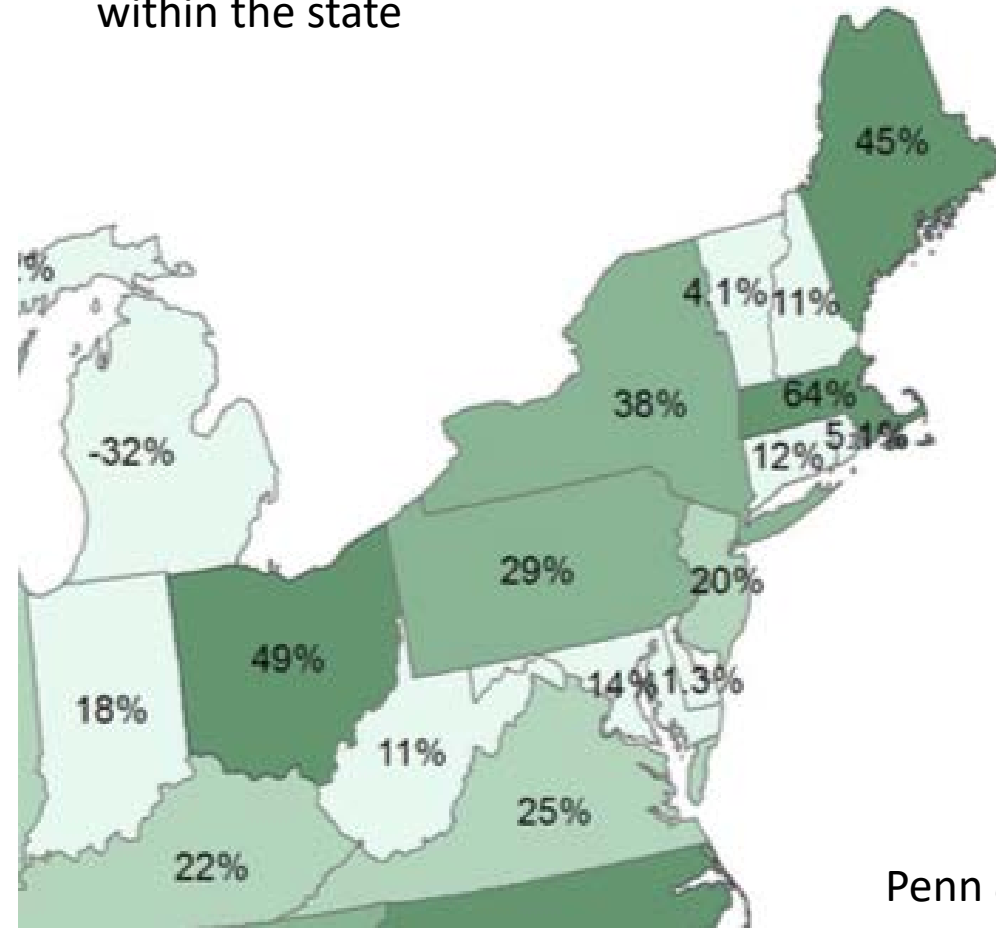- Produces county-level health benefits of statewide emissions reductions

Arunachalam *et al.* 2019

CMAQ DDM & BenMap – Sample Output
TCI results will be county level

Deaths due to air pollution
from residential fuel use
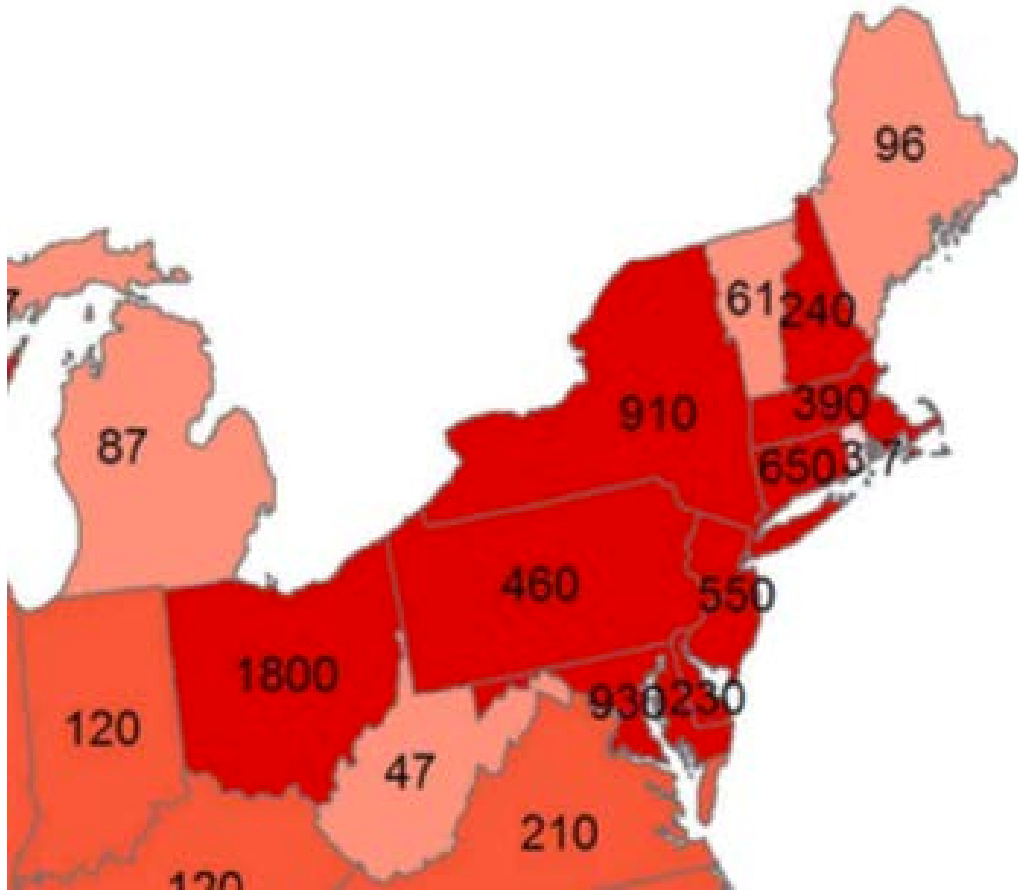
% of impact that originated
within the state

Penn *et. al* 2017
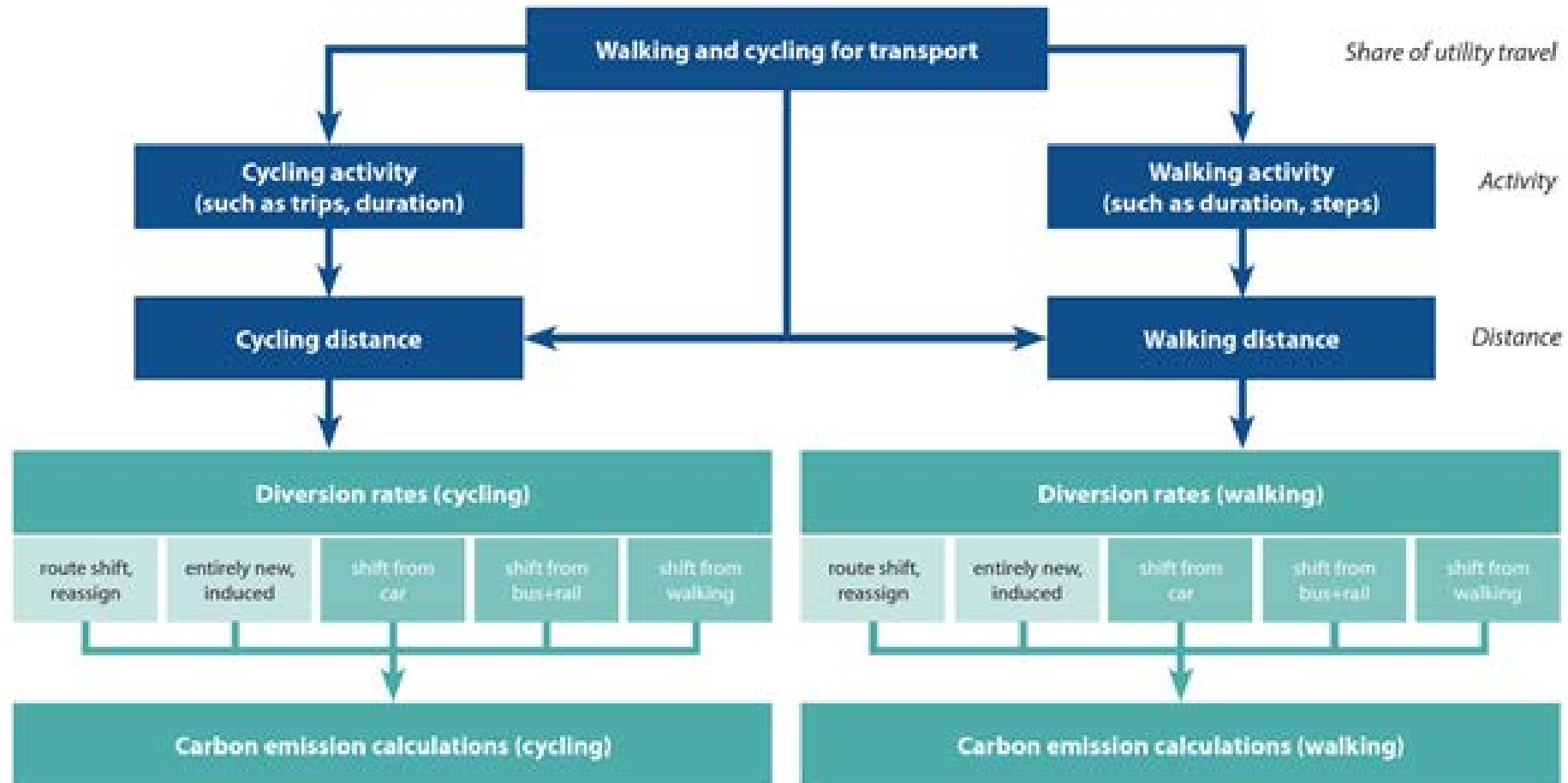
Equity Assessment

Where do emissions decrease and who lives in those counties?

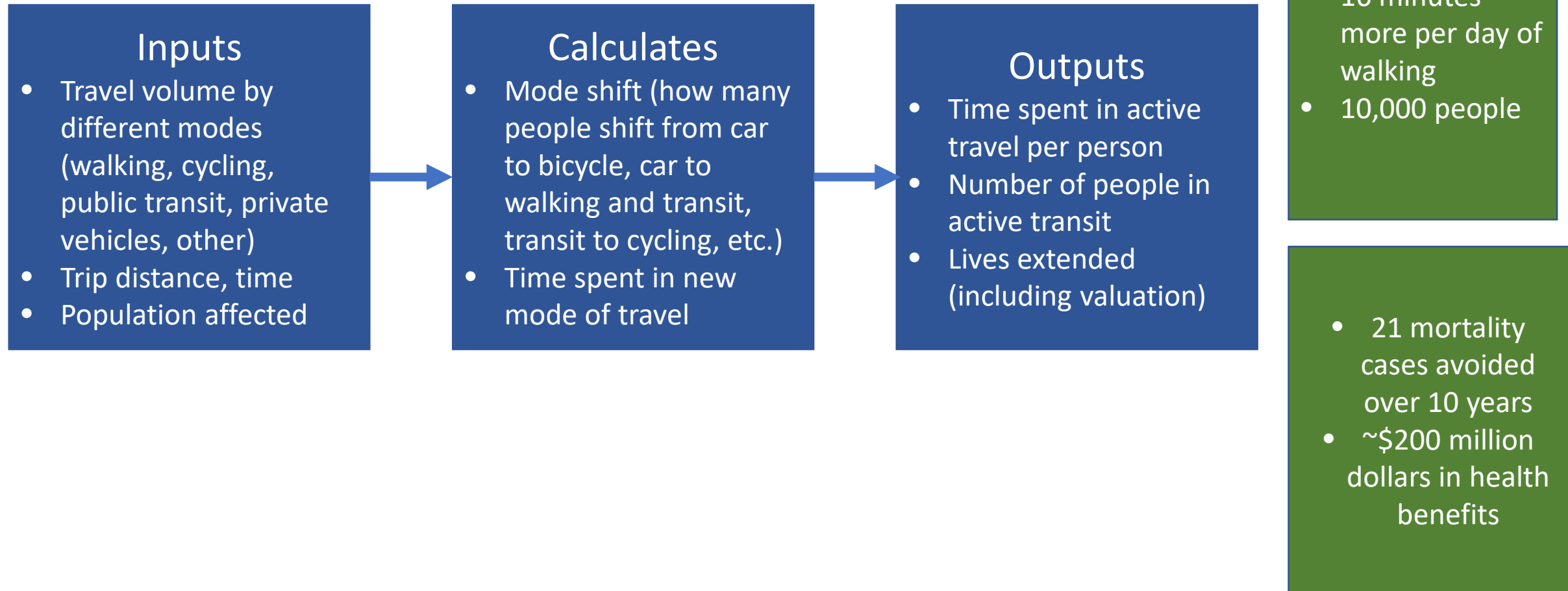Where does air quality improve and who lives in those counties?

Are there any areas where emissions increase and who is in those counties?

Are there areas where air pollution increases, and who is in those counties?

Physical Activity Benefits - HEAT Model

Physical Activity Benefits - HEAT

Inputs
- Travel volume by different modes (walking, cycling, public transit, private vehicles, other)
- Trip distance, time
- Population affected

→

Calculates
- Mode shift (how many people shift from car to bicycle, car to walking and transit, transit to cycling, etc.)
- Time spent in new mode of travel

→

Outputs
- Time spent in active travel per person
- Number of people in active transit
- Lives extended (including valuation)

- 16 minutes more per day of walking
- 10,000 people

- 21 mortality cases avoided over 10 years
- ~$200 million dollars in health benefits

5 Goals of Healthy Transportation Systems

1. Reduced deaths and disease from transport-generated pollution.

2. Reduced exposures of disadvantaged groups to excessive transport-related injuries and health risks.

3. Reduced climate change emissions from transport that contribute to future, as well as present-day, health impacts.

4. Increased physical activity, including through safe walking and bicycling

5. Safer and more efficient access, especially for vulnerable groups, to jobs, schools, services and social opportunities.

Adapted from WHO 2011

Thank you