Understanding the Health Implications of Climate Mitigation Strategies for Transportation

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

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

*Note: PM2.5 standard and average distances are approximate values.
On-Road Vehicle Emissions

- Exhaust emissions (CO, CO₂, HC, NO, PM)
- Refuelling losses (HC, VOC)
- Evaporative emissions (HC, VOC)
- Abrasion of tyres, brakes and clutch (PM)
- Re-suspension of road dust (PM)
- Road surface wear (PM)

Distance to Roads Matters

Graph showing the concentration of NO and PAH (mg/m³) vs. distance from a freeway. The concentration peaks near the freeway, with higher concentrations downwind compared to upwind. Smith 2013
Estimated Health & Climate Effects – Passenger Vehicles, 2015

<table>
<thead>
<tr>
<th>Health Effect</th>
<th>Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premature Mortality</td>
<td>1,316</td>
</tr>
<tr>
<td>ER Visits, Respiratory</td>
<td>466</td>
</tr>
<tr>
<td>Acute Bronchitis</td>
<td>1,294</td>
</tr>
<tr>
<td>Respiratory Symptoms</td>
<td>705,668</td>
</tr>
<tr>
<td>Work Loss Days</td>
<td>112,347</td>
</tr>
<tr>
<td>Asthma Exacerbation</td>
<td>109,637</td>
</tr>
<tr>
<td>Heart Attack</td>
<td>967</td>
</tr>
<tr>
<td>Hospitalizations: Respir. &amp; Cardio</td>
<td>488</td>
</tr>
</tbody>
</table>

Estimated Health and Climate Costs, 2015 (billion$)
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

<table>
<thead>
<tr>
<th>Effects</th>
<th>Land use and alternatives to private motorized transport</th>
<th>Pricing policies (vehicle &amp; fuel use, congestion)</th>
<th>Modified vehicles &amp; fuels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air pollution</td>
<td>++</td>
<td>- to ++</td>
<td>- to ++</td>
</tr>
<tr>
<td>Noise</td>
<td>++</td>
<td>0 to ++</td>
<td>0</td>
</tr>
<tr>
<td>Traffic injury/fatality</td>
<td>++</td>
<td>0 to ++</td>
<td>0</td>
</tr>
<tr>
<td>Physical activity</td>
<td>++</td>
<td>0 to ++</td>
<td>0</td>
</tr>
<tr>
<td>Social effects</td>
<td>++</td>
<td>0 to ++</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Measure</th>
<th>Benefits in 2030</th>
<th>Monetized value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate</td>
<td>12-72 mmt GHG avoided</td>
<td>$480-2880</td>
</tr>
<tr>
<td>Air pollution</td>
<td>19 deaths prevented</td>
<td>$152</td>
</tr>
<tr>
<td>Traffic injuries/fatalities</td>
<td>166 fatalities prevented</td>
<td>$1494</td>
</tr>
<tr>
<td><strong>Physical activity</strong></td>
<td><strong>420 deaths prevented</strong></td>
<td><strong>$2941</strong></td>
</tr>
<tr>
<td>Pavement damage</td>
<td>Avoided maintenance costs</td>
<td>$408</td>
</tr>
</tbody>
</table>

Adapted from Cambridge Systematics 2015
<table>
<thead>
<tr>
<th>Effect</th>
<th>Benefits of retaining 53-64 million trips on public transit</th>
<th>Monetized value (annual; millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air pollution</td>
<td>Avoid 0.26 additional deaths/yr</td>
<td>$2.1</td>
</tr>
<tr>
<td></td>
<td>Avoid 0.24 additional/yr hospitalizations</td>
<td></td>
</tr>
<tr>
<td>Noise</td>
<td>Avoid exposure of 2000 people to increase of 60dB of noise on average per day</td>
<td>-</td>
</tr>
<tr>
<td>Traffic injury/fatalities</td>
<td>Avoid 1.15 new deaths/yr</td>
<td>$48.8</td>
</tr>
<tr>
<td>Physical Activity</td>
<td>Avoid 14 additional deaths/yr</td>
<td>$116.5</td>
</tr>
<tr>
<td>Social effects</td>
<td>2200 public transportation-dependent households retain access to healthcare resources</td>
<td>-</td>
</tr>
</tbody>
</table>
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

- 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
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
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