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Background

Green House Gas Emissions

• California’s motorized transport sector accounts for 38% of greenhouse gas emissions, GHG (226 MMT CO$_2$E in 2003)

• Pathways to reduce GHG emissions is through vehicle miles traveled
  ✓ Increased efficiency of fuel and vehicles
  ✓ Reducing vehicle miles traveled (less trips, mode switching (SOV to mass transport), walking/bicycling (active transport)
Background

Health Status

• Health status of a population is combined influence of biological and environmental factors whose pathways traverse individuals, families, neighborhoods, communities, regions, and nations – social determinants of health

• Public health meets urban planning: policies and practice that influence the built environment (housing, transportation, infrastructure, economy) are key determinants of population health (Sustainable Communities, HiAP, AN32/SB375)

• Strategies to reduce GHG emissions influence the built environment in a way that impacts population health
  ✔ Do the strategies generate health co-benefits or harms?
  ✔ What strategies yield significant health co-benefits?
  ✔ How do we measure this?
Aims and Objectives of the Woodcock Model*

- To estimate the health impacts of alternative strategies for reducing carbon dioxide emissions from transport.
  - Lower carbon driving
    - Lower carbon emission motor vehicles
  - Increased active travel
    - Replacing urban car and motorcycle trips with walking or bicycling.


Note: following slides courtesy of James Woodcock et al.
Pathways: Modelled and Not Modelled

Legend

- **Health effects modelled**
- **Health effects not modelled**

**Lower Carbon Driving**
- Resource use
- Greenhouse gases
- Economic growth
- Ecological stress
- Opportunity cost
- Energy conflict

**More Active Travel**
- Pollutants
- Noise pollution
- Physical activity
- Kinetic energy/danger
- Community severance
- Injuries

**Multiple health outcomes**

**Multiple health outcomes**

**Air pollution**

**Energy conflict**

**Pathways:** Modelled and Not Modelled
Health Outcomes and Pathways

• Based on strong quantitative evidence of a link between exposure pathways and health outcomes, the following pathways were chosen:

✓ Physical Activity

<table>
<thead>
<tr>
<th>Condition</th>
<th>Studies included</th>
<th>Relative Risk</th>
<th>Exposure (Metabolic Equivalents)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast cancer</td>
<td>19 cohort studies, 29 case control studies</td>
<td>0.94</td>
<td>each additional h/wk</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>18 cohort studies (459,833 people, 19,249 cases)</td>
<td>0.84</td>
<td>3 hrs walking per week (7.5 METs/wk)</td>
</tr>
<tr>
<td>Colon cancer</td>
<td>15 cohorts (7873 cases)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td>Cohort study (10,201 men, 387 first episodes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>physician-diagnosed depression)</td>
<td>1</td>
<td>&lt;1000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.83</td>
<td>1000-2499</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.72</td>
<td>2500+</td>
</tr>
<tr>
<td>Diabetes</td>
<td>10 cohort studies (301,211 people, 9367 cases)</td>
<td>0.83</td>
<td>10 METs/wk</td>
</tr>
</tbody>
</table>

Metabolic Equivalent is amount of energy expended of a person at rest (1 MET = 1 kcal/kg/hr)

✓ Road Traffic Injury

✓ Air pollution (respiratory disease, lung cancer)
Target Population

- Target Population: Greater London (7.5 million in 610 sq. mi)
  - Greater London Authority adopted a GHG emission reduction target of 60% reduction from 1990 baseline by 2025 and 80% by 2050
Scenario Construction

• VIBAT, Visioning and Backcasting for Transport in London
  ✓ Current and projected CO₂ emission trends
  ✓ Range of policy packages of mitigation options
    (Low emission vehicles, alternative fuels, pricing regimes, public transport, walking and bicycling, strategic and urban planning, information and communication policies, smarter choice measures, ecologic driving and slower speeds, long distance travel substitution, freight transport)

• TC-SIM: interactive simulation tool that allows users to make choices about their future lifestyles in order to reduce transport carbon emissions
  (www.vibat.org/vibat_ldn/tcsim.shtml)
# Annual CO₂ Emissions Total and per Capita for London

<table>
<thead>
<tr>
<th>Baselines and Scenarios</th>
<th>Aggregate Transport CO₂ Emissions (tons)</th>
<th>CO₂ Emissions Reduction on 1990 (%)</th>
<th>Population (millions)</th>
<th>Transport CO₂ Emissions Per Person (tCO₂/person)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>9,647,900</td>
<td>-2.5%</td>
<td>7.5</td>
<td>1.29</td>
</tr>
<tr>
<td>2010</td>
<td>9,935,897</td>
<td>0%</td>
<td>7.8</td>
<td>1.27</td>
</tr>
<tr>
<td>2030 Business as Usual (BAU)</td>
<td>10,381,318</td>
<td>+4%</td>
<td>8.6</td>
<td>1.17</td>
</tr>
<tr>
<td>2030 Lower Carbon Emission Motor Vehicles (LC)</td>
<td>6,480,565</td>
<td>-35%</td>
<td>8.6</td>
<td>0.73</td>
</tr>
<tr>
<td>2030 Increased Active Travel (AT)</td>
<td>6,120,306</td>
<td>-38%</td>
<td>8.6</td>
<td>0.69</td>
</tr>
<tr>
<td>2030 Sustainable Trajectory (AT + LC)</td>
<td>3,991,893</td>
<td>-60%</td>
<td>8.6</td>
<td>0.45</td>
</tr>
</tbody>
</table>
# Annual Distance Travelled and CO₂ Emissions per Person, London, by Scenario

<table>
<thead>
<tr>
<th>Baseline and Scenario</th>
<th>Car</th>
<th>Bus</th>
<th>Rail</th>
<th>Heavy Trucks</th>
<th>Walking</th>
<th>Bicycle</th>
<th>Motorcycle</th>
<th>Total Km Distance</th>
<th>Tons CO₂ Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>5,599</td>
<td>1,110</td>
<td>2,630</td>
<td>244</td>
<td>262</td>
<td>151</td>
<td>70</td>
<td>10,065</td>
<td>1.27</td>
</tr>
<tr>
<td>2030 BAU</td>
<td>5,053</td>
<td>1,044</td>
<td>2,776</td>
<td>217</td>
<td>233</td>
<td>137</td>
<td>69</td>
<td>9,528</td>
<td>1.17</td>
</tr>
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<td>Lower-carbon emission motor vehicles</td>
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<td>3,698</td>
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<td>173</td>
<td>573</td>
<td>1239</td>
<td>25</td>
<td>9,528</td>
<td>0.69</td>
</tr>
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<td>Towards sustainable transport</td>
<td>3,698</td>
<td>1,044</td>
<td>2,776</td>
<td>173</td>
<td>573</td>
<td>1239</td>
<td>25</td>
<td>9,528</td>
<td>0.45</td>
</tr>
</tbody>
</table>

**London travel patterns**

- Baseline
- 2030: Lower Carbon Driving
- 2030: Increased Active Travel
Data and Methods for Assessing Health Outcomes for Active Transport

- Global Burden of Disease Database, WHO
  - Breakdown of Disability Adjusted Life Years (DALYs) by country, age, sex, and health outcome
  - DALY is a measure of premature mortality and disability based on the years of life lost, YLL (years of expected life - age at death) + years lived with a disability, YLD
    \[
    \text{DALY} = \text{YLL} + \text{YLD}
    \]
- Comparative Risk Assessment: Calculates the difference in DALYs between 2 different scenarios
  - Step 1: Attributable Fraction (fraction of DALYs attributable to difference in scenarios)
    - Population distribution of physical activity level under BAU is derived from travel surveys
    - Population distribution of physical activity under active transport scenario is based on blend of travel survey data from London, UK, and several European cities that have high levels of walking and bicycling (Delft, Netherlands; Freiberg, Germany; Copenhagen, Denmark)
Data and Methods for Assessing Health Outcomes for Active Transport

- Modeling population distribution of weekly hours of physical activity

  ![Graph showing baseline and active transport distribution](image)

- Hours of physical activity per week is converted to weekly calorie expenditures (MET hours/wk) based on age- and sex-specific walking and bicycling speeds (Ainsworth et al, 2000)

- Non active transport activity is based on population health surveys
Data and Methods for Assessing Health Outcomes for Active Transport

- Physical activity-health outcome relationship (dose-response) is based on pooled studies from a literature review and some additional

- Non active transport activity is based on population health surveys

- Step 2: Health Benefit/Harm = AF × Total DALYs
  - Benefits from physical activity and air pollution reduction
  - Harms from increased pedestrian and bicyclist exposure to motor vehicles and injuries from collisions, although “safety in numbers” may diminish risk
  - Specific to age, sex, and health outcome, summed up and expressed per million population
Results of Comparative Risk Assessment

DALYs per Million Population from Travel Scenarios*, London, 2030

* Compared to Business as Usual, London, 2030
## Health Impacts of Combination Scenario

<table>
<thead>
<tr>
<th>Disease</th>
<th>Change in disease burden</th>
<th>Change in premature deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ischemic heart disease</td>
<td>10-19%</td>
<td>1950-4240</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>10-18%</td>
<td>1190-2580</td>
</tr>
<tr>
<td>Dementia</td>
<td>7-8%</td>
<td>200-240</td>
</tr>
<tr>
<td>Breast cancer</td>
<td>12-13%</td>
<td>200-210</td>
</tr>
<tr>
<td>Road traffic crashes</td>
<td>19-39%</td>
<td>50-80</td>
</tr>
</tbody>
</table>
# Potential Data Sources for Replicating Woodcock’s Active Transport Model in California

<table>
<thead>
<tr>
<th>Model Parameter</th>
<th>Woodcock Data Source(s)</th>
<th>Comment</th>
<th>Potential California Source(s)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>DALY, condition specific, age-sex stratified</td>
<td>Global Burden of Disease Database</td>
<td>Age strata (0-4, 5-14, 15-29, 30-44, 45-59, 60-69, 70-79, 80+)</td>
<td>Same as Woodcock (GBD)</td>
<td>• Special request to WHO/Mathers et al</td>
</tr>
<tr>
<td>RR</td>
<td>Meta-analyses from an exhaustive literature review</td>
<td>Modeled dose-response curves</td>
<td>Same as Woodcock</td>
<td>• Need to consult with Woodcock for unpublished details</td>
</tr>
<tr>
<td>Distance traveled by mode for each scenario</td>
<td>London-area travel demand models and travel surveys</td>
<td>Scenario construction based on CO₂ reduction targets</td>
<td>MPO’s travel forecasts, modified for active transport</td>
<td>• Need to set specific targets and reverse engineer cycling and walking distances; factor in clean fuels/lower emission vehicles scenarios</td>
</tr>
<tr>
<td>Population distribution of active travel time</td>
<td>London Area Travel Survey (LATS), 1 day travel diary National (UK) Travel Survey, 5-day travel diary</td>
<td>Modeled coefficient of variation of daily vs. weekly travel times to compensate for LATS short sample duration and model’s requirement for weekly exposures</td>
<td>Bay Area Travel Survey Southern California travel survey (SCAG), California (CalTrans) National Household Travel Survey</td>
<td>• Same issue of modeling 1-2 day vs. weekly travel dairies; • Need to contact Woodcock for unpublished details</td>
</tr>
<tr>
<td>Travel speeds for walking and cycling, age-sex stratified</td>
<td>LATS</td>
<td></td>
<td>Same as above</td>
<td></td>
</tr>
<tr>
<td>Ratios of cycling:walking travel times, age-sex stratified</td>
<td>LATS and data from the Netherlands</td>
<td>Upper limit set at cycling and walking times achieved in several European cities</td>
<td>Same as above</td>
<td>• What is an appropriate upper limit for Active Transport scenario? Travel characteristics of California or U.S. cities vs. European cities</td>
</tr>
<tr>
<td>MET for walking and cycling at varying speeds</td>
<td>Compendium of physical activities</td>
<td></td>
<td>Compendium of physical activities</td>
<td>• Public domain data</td>
</tr>
<tr>
<td>MET hours in non-transport physical activity</td>
<td>Health Survey for England; STEPS risk factor surveillance</td>
<td></td>
<td>California Health Interview Survey</td>
<td>• CHIS 2005 adult questionnaire items on minutes/day and days per week of walking and other physical activity</td>
</tr>
</tbody>
</table>
Can Woodcock’s Active Transport Model Be Reproduced for Regional Transportation Plans in California?

• California has comparable travel survey and health data
• Woodcock’s group has done the heavy lifting on methods.
• Looks optimistic that the Woodcock model can be reproduced for regions covered by California’s MPOs
• Implementing the Woodcock Model in California will help answer:
  ✓ Can California reap large health co-benefits from active transport?
  ✓ What interventions/policies would promote active transport at a level to generate co-benefits
  ✓ Can MPOs take advantage of this approach in crafting their plans?
Bibliography and Potential Data Sources