Public Health Benefits of Walking and Bicycling to Reduce Greenhouse Gas Emissions: The Woodcock Model of Active Transport

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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_2E 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.

* Woodcock J, Edwards P, Tonne C, Armstrong BG, Ashiru O, Banister D, et al. Public health benefits of strategies to reduce greenhouse-gas emissions: urban land transport. The Lancet 2009;374:1930-1943.

Note: following slides courtesy of James Woodcock et al.

Pathways: Modelled and Not Modelled
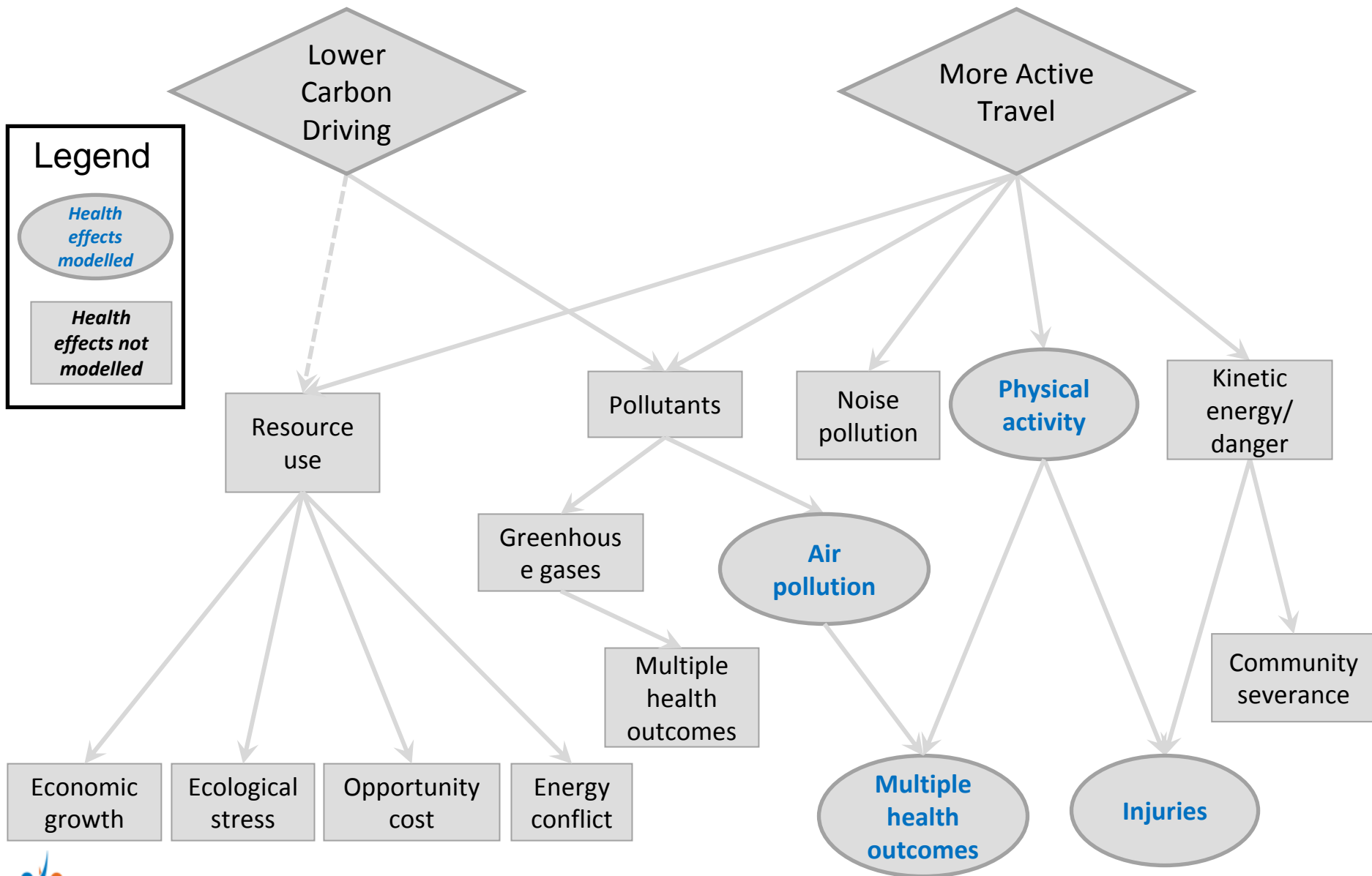
Health Outcomes and Pathways

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

  ✓ Physical Activity

Condition	Studies included	Relative Risk	Exposure (Metabolic Equivalents)*
Breast cancer	19 cohort studies, 29 case control studies	0.94	each additional h/wk
Cardiovascular diseases	18 cohort studies (459,833 people, 19,249 cases)	0.84	3 hrs walking per week (7.5 METs/wk)
Colon cancer	15 cohorts (7873 cases)	Women: 0.80	30.1 METs/wk
		Men: 0.86	30.9 METs/wk
Depression	Cohort study (10,201 men, 387 first episodes physician-diagnosed depression)		Kcal/wk
		1	<1000
		0.83	1000-2499
		0.72	2500+
Diabetes	10 cohort studies (301,211 people, 9367 cases)	0.83	10 METs/wk

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
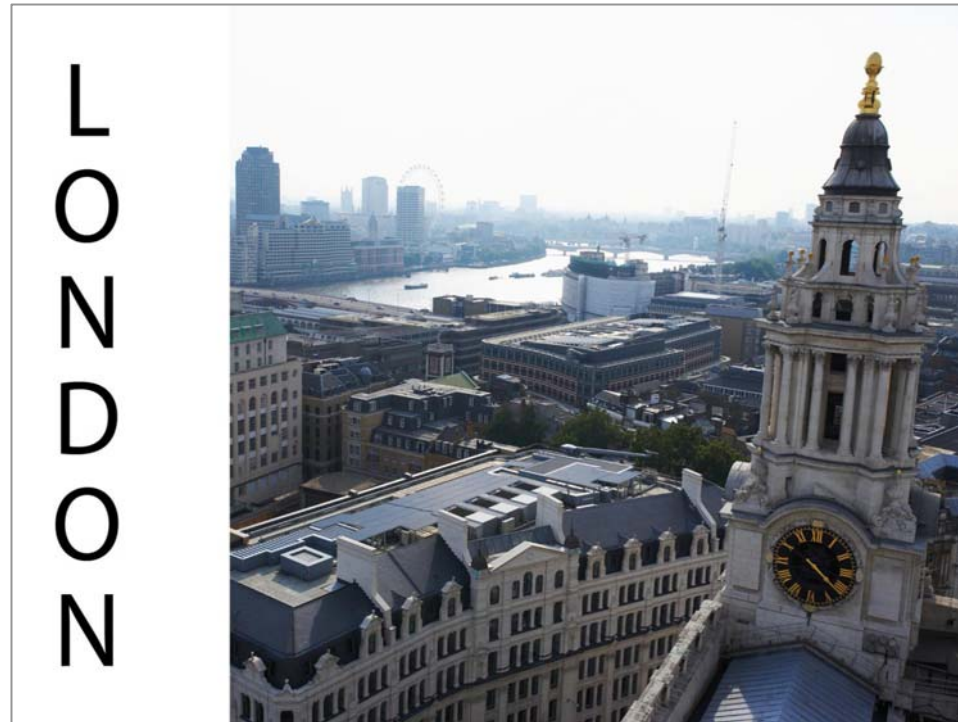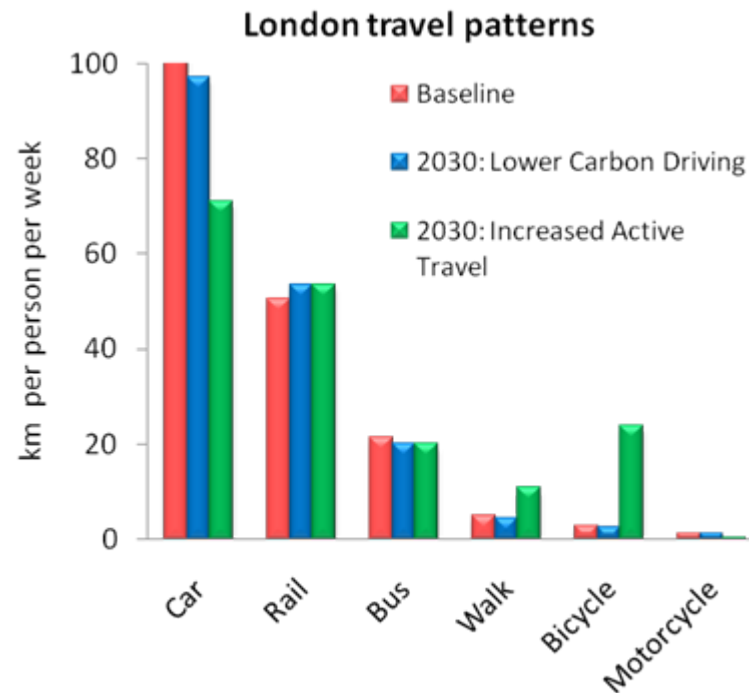
Scenario Construction

- VIBAT, Visioning and Backcasting for Transport in London
  - ✓ Current and projected CO_2 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 CO_2 Emissions Total and per Capita for London

Baselines and Scenarios	Aggregate Transport CO_2 Emissions (tons)	CO_2 Emissions Reduction on 1990 (%)	Population (millions)	Transport CO_2 Emissions Per Person (tCO_2/person)
2006	9,647,900	-2.5%	7.5	1.29
2010	9,935,897	0%	7.8	1.27
2030 Business as Usual (BAU)	10,381,318	+4%	8.6	1.17
2030 Lower Carbon Emission Motor Vehicles (LC)	6,480,565	-35%	8.6	0.73
2030 Increased Active Travel (AT)	6,120,306	-38%	8.6	0.69
2030 Sustainable Trajectory (AT + LC)	3,991,893	-60%	8.6	0.45

Annual Distance Travelled and CO$_2$ Emissions per Person, London, by Scenario

Baseline and Scenario	Car	Bus	Rail	Heavy Trucks	Walking	Bicycle	Motor-cycle	Total Km Distance	Tons CO$_2$ Emissions
2010	5,599	1,110	2,630	244	262	151	70	10,065	1·27
2030 BAU	5,053	1,044	2,776	217	233	137	69	9,528	1·17
Lower-carbon emission motor vehicles	5,053	1,044	2,776	217	233	137	69	9,528	0·73
Increased active travel	3,698	1,044	2,776	173	573	1239	25	9,528	0·69
Towards sustainable transport	3,698	1,044	2,776	173	573	1239	25	9,528	0·45

London travel patterns

Legend:
- Baseline
- 2030: Lower Carbon Driving
- 2030: Increased Active Travel

y-axis: km per person per week
x-axis: Car, Rail, Bus, Walk, Bicycle, Motorcycle

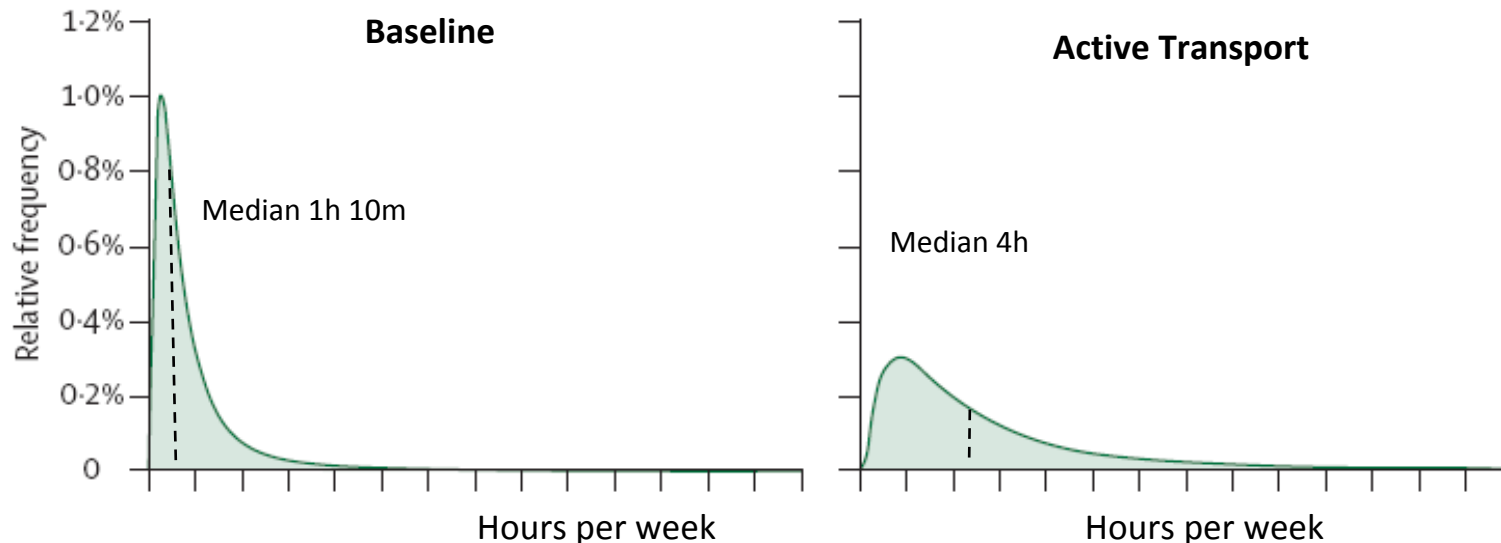## Data and Methods for Assessing Health Outcomes for Active Transport

- 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

$$DALY = YLL + YLD$$

- 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)

- Modeling population distribution of weekly hours of physical activity

Baseline

Active Transport

Median 1h 10m

Median 4h

Relative frequency

1·2%
1·0%
0·8%
0·6%
0·4%
0·2%
0

Hours per week

Hours per week

- 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

- Physical activity-health outcome relationship (dose-response) is based on pooled studies from a literature review and some additional
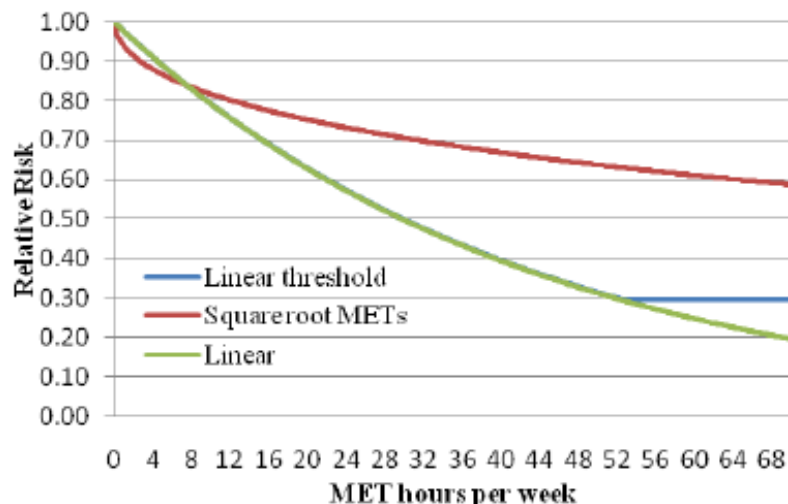
- Non active transport activity is based on population health surveys
- Step 2: Health Benefit/Harm = AF × Total DALYs
  - ✓ Benefits from physical activity and air pollution reduction
  - ✓ Harms from increased pedestrian and bicyclist exposure to motor vehicles and injuries from collisions, although "safety in numbers" may diminish risk
  - ✓ Specific to age, sex, and heath outcome, summed up and expressed per million population

Results of Comparative Risk Assessment

DALYs per Million Population from Travel Scenarios*, London, 2030
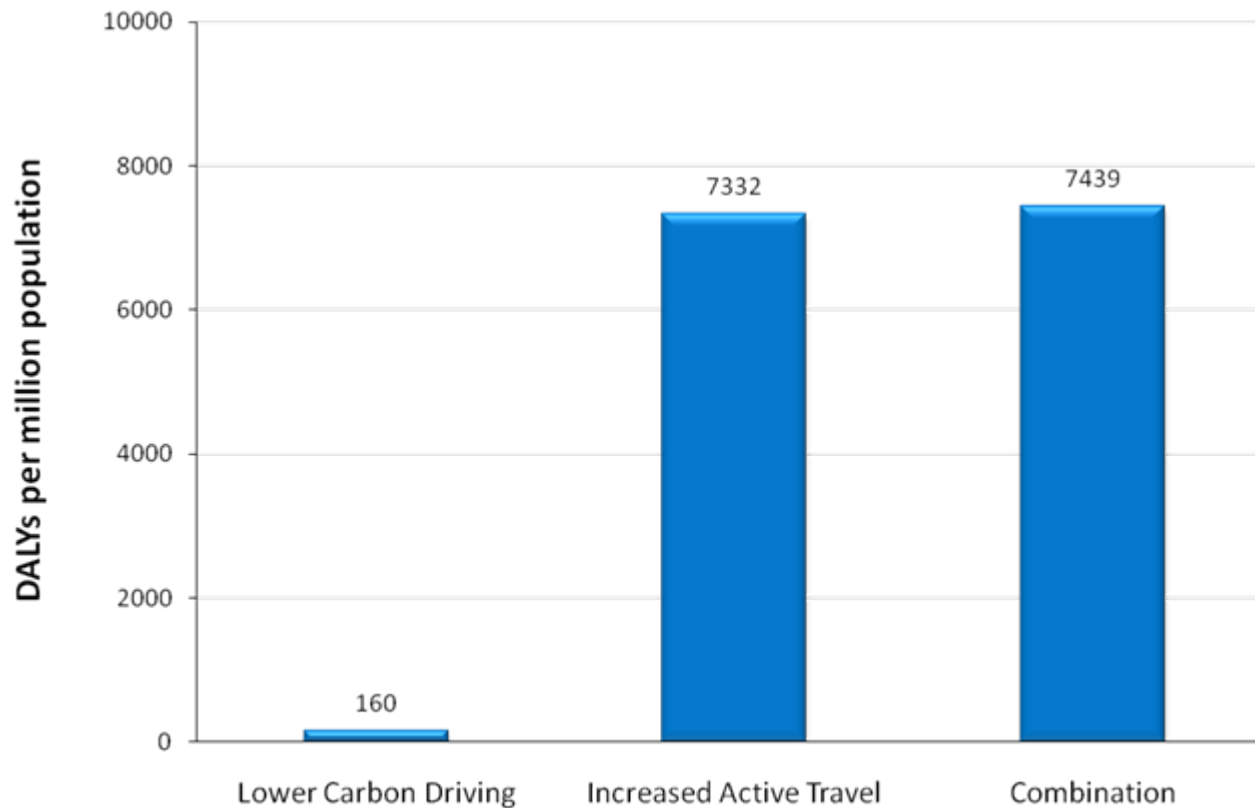
* Compared to Business as Usual, London, 2030

Health Impacts of Combination Scenario

	Change in disease burden	Change in premature deaths
Ischemic heart disease	10-19%	1950-4240
Cerebovascular disease	10-18%	1190-2580
Dementia	7-8%	200-240
Breast cancer	12-13%	200-210
Road traffic crashes	19-39%	50-80

Potential Data Sources for Replicating Woodcock's Active Transport Model in California

Model Parameter	Woodcock Data Source(s)	Comment	Potential California Source(s)	Comment
DALY, condition specific, age-sex stratified	Global Burden of Disease Database	Age strata (0-4, 5-14, 15-29, 30-44, 45-59, 60-69, 70-79, 80+)	Same as Woodcock (GBD)	• Special request to WHO/Mathers et al
RR	Meta-analyses from an exhaustive literature review	Modeled dose-response curves	Same as Woodcock	• Need to consult with Woodcock for unpublished details
Distance traveled by mode for each scenario	London-area travel demand models and travel surveys	Scenario construction based on CO_2 reduction targets	MPO's travel forecasts, modified for active transport	• Need to set specific targets and reverse engineer cycling and walking distances; factor in clean fuels/low emission vehicles scenarios
Population distribution of active travel time	London Area Travel Survey (LATS), 1 day travel diary National (UK) Travel Survey, 5-day travel diary	Modeled coefficient of variation of daily vs. weekly travel times to compensate for LATS short sample duration and model's requirement for weekly exposures	Bay Area Travel Survey Southern California travel survey (SCAG), California (CalTrans) National Household Travel Survey	• Same issue of modeling 1-2 day vs. weekly travel dairies; • Need to contact Woodcock for unpublished details
Travel speeds for walking and cycling, age-sex stratified	LATS		Same as above	
Ratios of cycling:walking travel times, age-sex stratified	LATS and data from the Netherlands	Upper limit set at cycling and walking times achieved in several European cities	Same as above	• What is an appropriate upper limit for Active Transport scenario? Travel characteristics of California or U.S. cities vs. European cities
MET for walking and cycling at varying speeds	Compendium of physical activities		Compendium of physical activities	• Public domain data
MET hours in non- transport physical activity	Health Survey for England; STEPS risk factor surveillance		California Health Interview Survey	• CHIS 2005 adult questionnaire items on minutes/day and days per week of walking and other physical activity

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?

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