Introduction to California ITHIM: Principles and Practice

Neil Maizlish, PhD, MPH, Epidemiologist
University of California, Davis

California ITHIM Workshop

I. Introduction

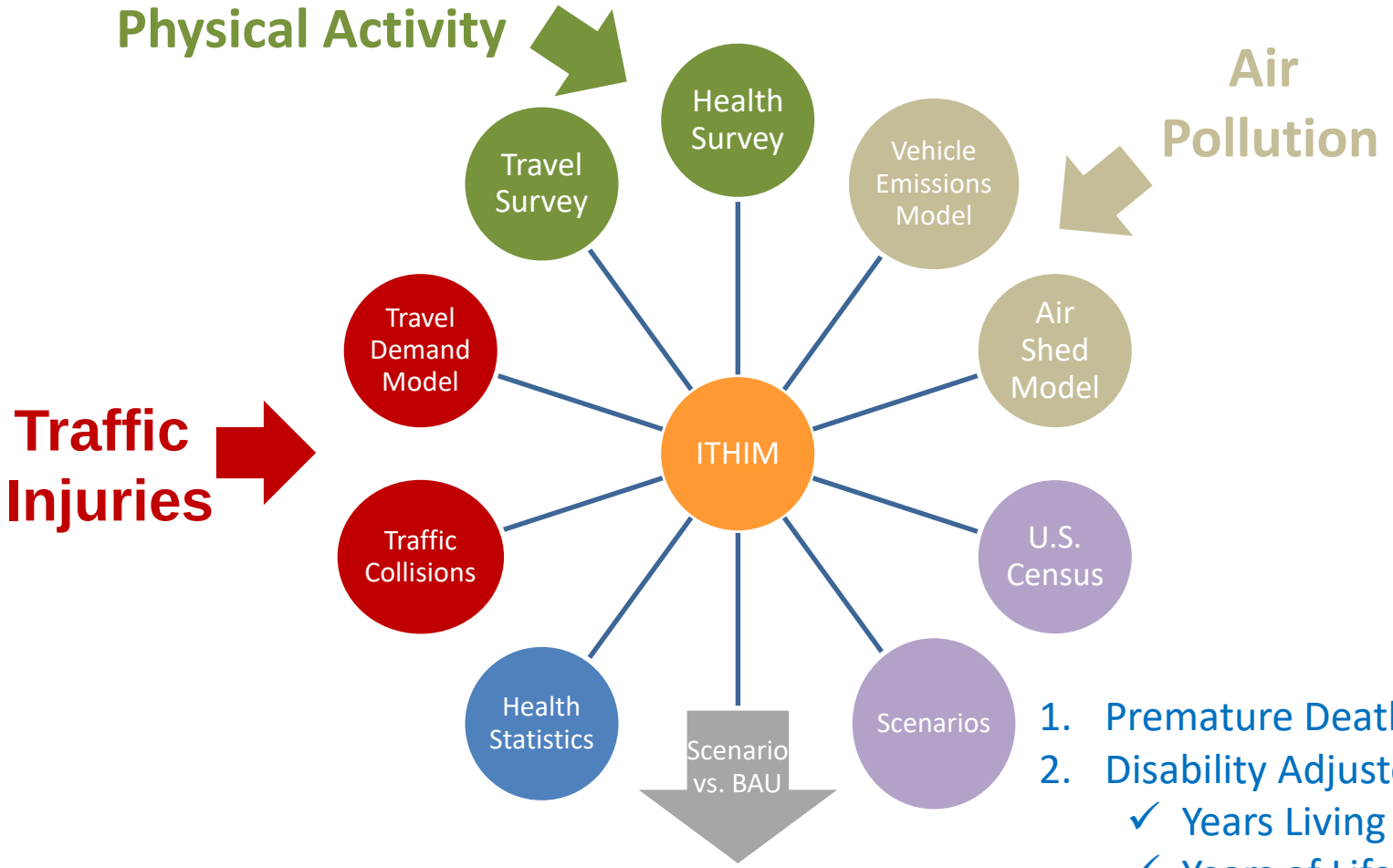
II. Principles
   A. Health Outcomes
   B. Comparative Risk Assessment
   C. Exercise
   D. Strengths, Assumptions, Limitations

III. Practice – User's Guide to California ITHIM
   A. Home Page
   B. About Pages
   C. RunITHIM Tool page
   D. Decision Support Pages
   E. User Support Pages

Glossary

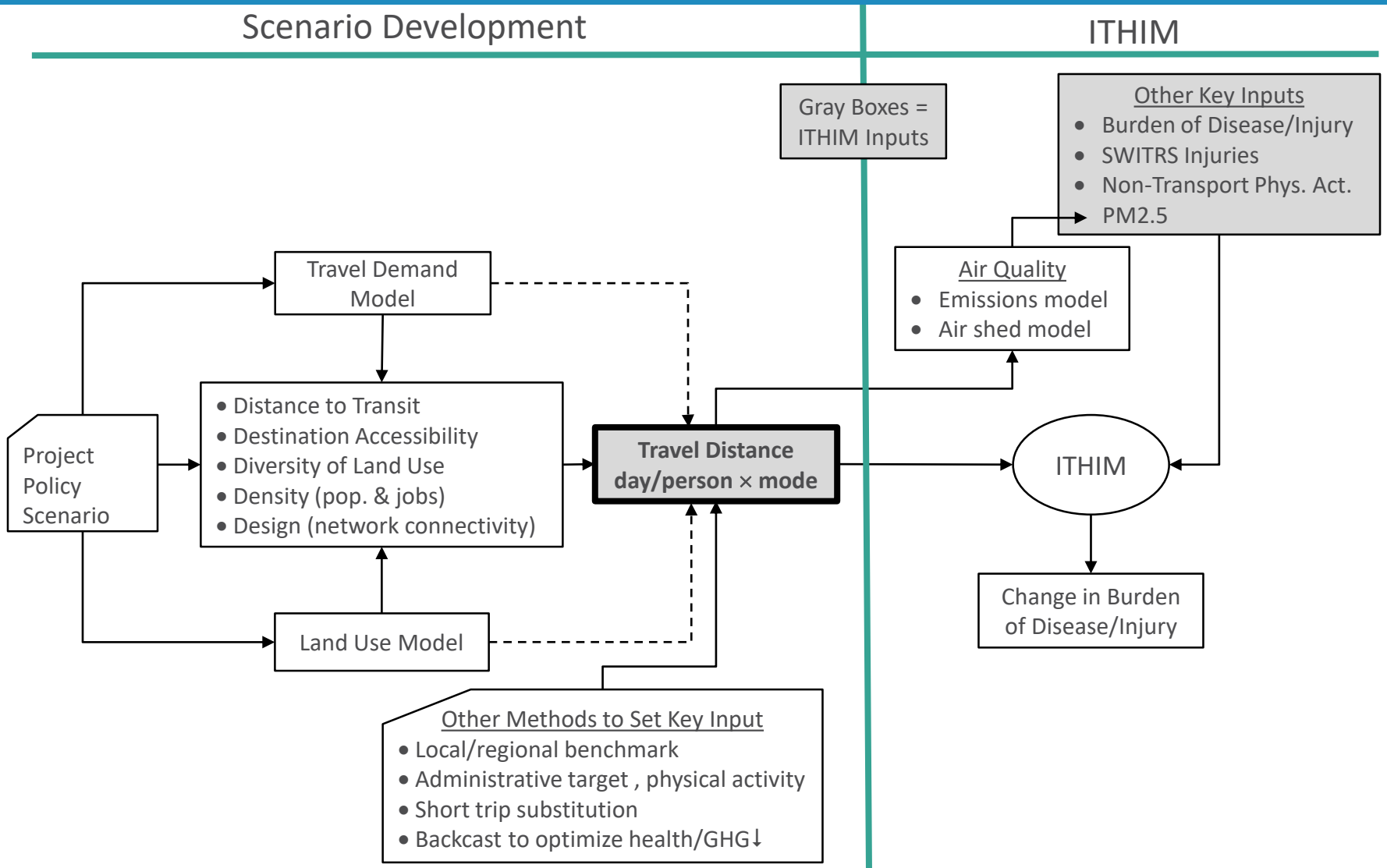
Acronym	Definition
ABM	Activity-Based (Travel Demand) Model
BAU	Business as Usual
BD	Burden of Disease (includes injury)
CARB	California Air Resources Board
CDPH	California Department of Public Health
CHTS	California Household Travel Survey
CHIS	California Health Interview Survey
CRA	Comparative Risk Assessment
CV	Coefficient of variation (standard deviation/mean)
CVD	Cardiovascular Disease
CSS	Cascading style sheet
DALY	Disability Adjusted Life Year = Years of Life Lost + Years Living with Disability
EMFAC	EMissionFACtorsmodel
GBD	Global Burden of Disease (includes injury)
HHD	Hypertensive heart disease
HTML	Hypertext Markup Language
ICD	International Classification of Diseases (5-digit hierarchical code)
IDE	Integrated development environment
ITHIM	Integrated Travel and Health Impacts Model
MPO	Metropolitan Planning Organization
PA	Physical Activity
PAF	Population Attributable Fraction
PM2.5	Particulate matter with an aerodynamic diameter of 2.5 microns or less
PMT	Personal Miles Traveled (VMT and PMT are related through occupancy)
R	Free, open source statistical computing language
RR	Relative Risk (ratio of disease or injury rate in population with exposure divided by the rate of disease/injury in a non-exposed population
RTI	Road Traffic Injuries
shiny	An R package that generates HTML to create web pages of R outputs
SWITRS	Statewide Integrated Traffic Records System
VMT	Vehicle Miles Traveled
WHO	World Health Organization
YLD	Years Living with Disability
YLL	Years of Life Lost

I. Introduction: What is ITHIM and What Does it Do?
The ITHIM Model Integrates Data on Health and Travel

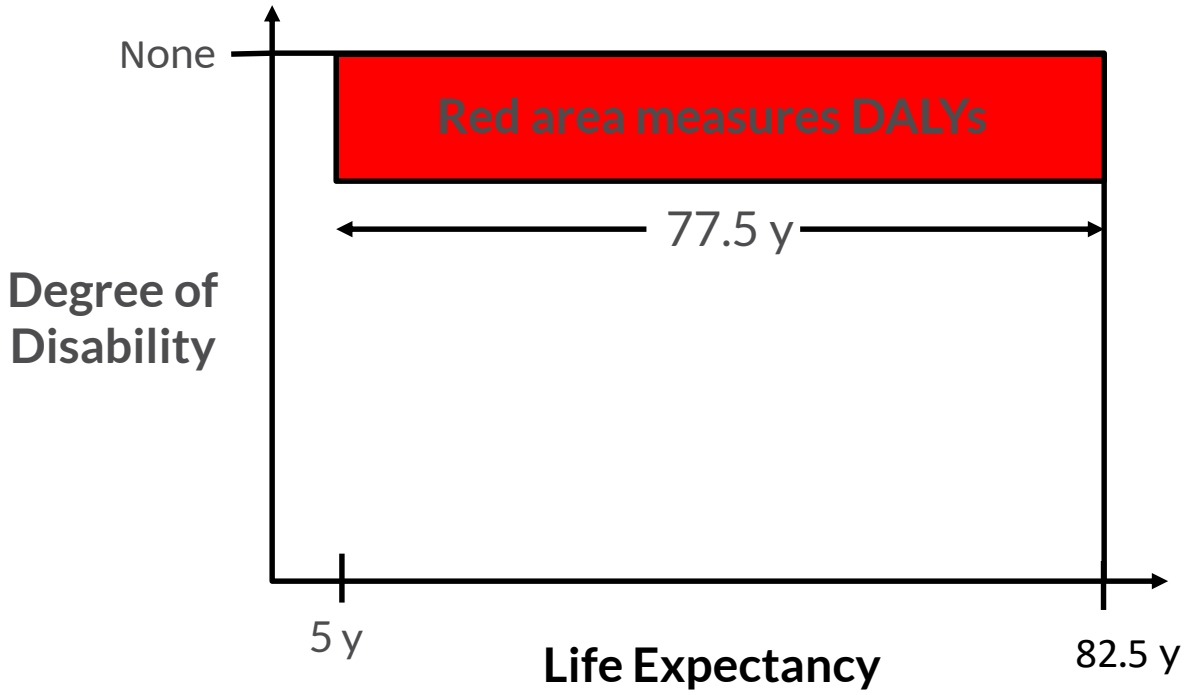


1. Premature Deaths
2. Disability Adjusted Life Years
   - ✓ Years Living with Disability
   - ✓ Years of Life Lost
3. Costs

What California ITHIM Doesn't Do – Scenario Development vs. Health Co-benefits Calculation

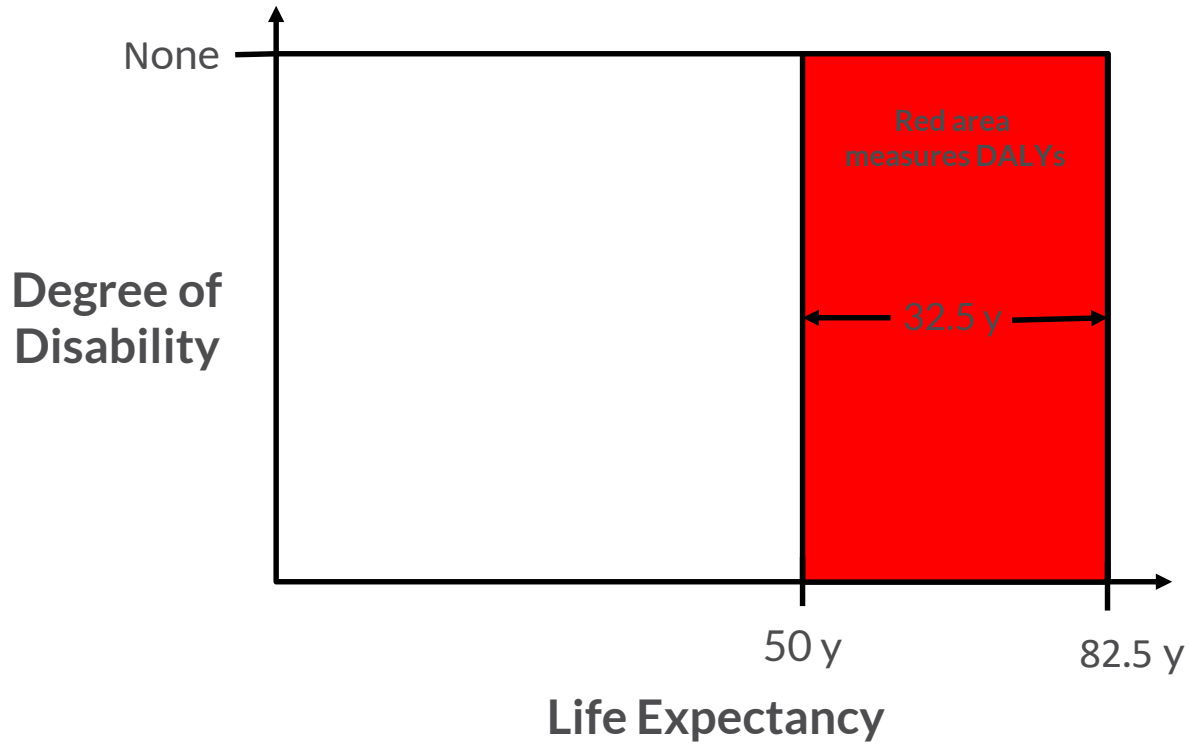


II. Principles: Health Outcomes
Disability Adjusted Life Years, DALY
a. Years Due to Living with Disability (YLD)



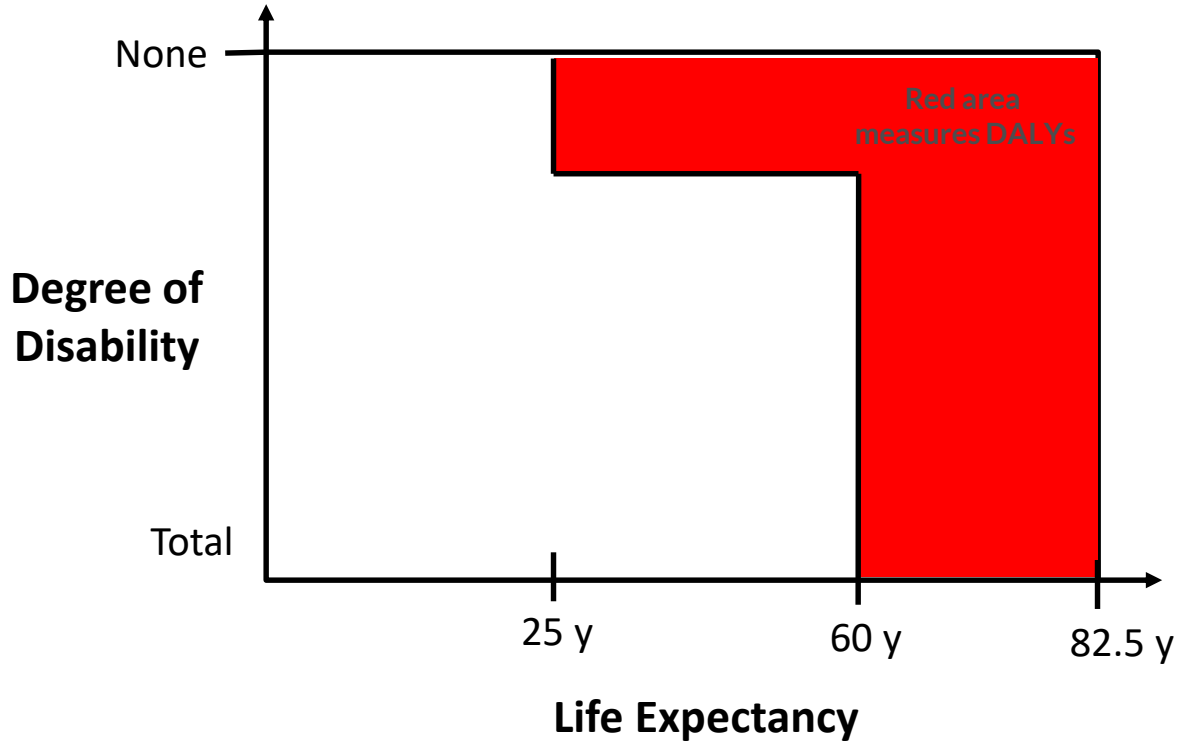
- Optimum life span (82.5 females, 80.0 males)
- At 5 years of age, girl loses leg in car crash and lives her expected life span
- Her loss is 77.5 years, adjusted by a disability weight
- If the weight is 0.3 her loss is 0.3 × 77.5 or 23.3 disability adjusted life years

b. DALYs Due to Premature Death (Years of Life Lost)



- At 50 years of age, a woman dies from a sudden heart attack
- Her loss is 32.5 years
- "Disability" weight is set at 1.0

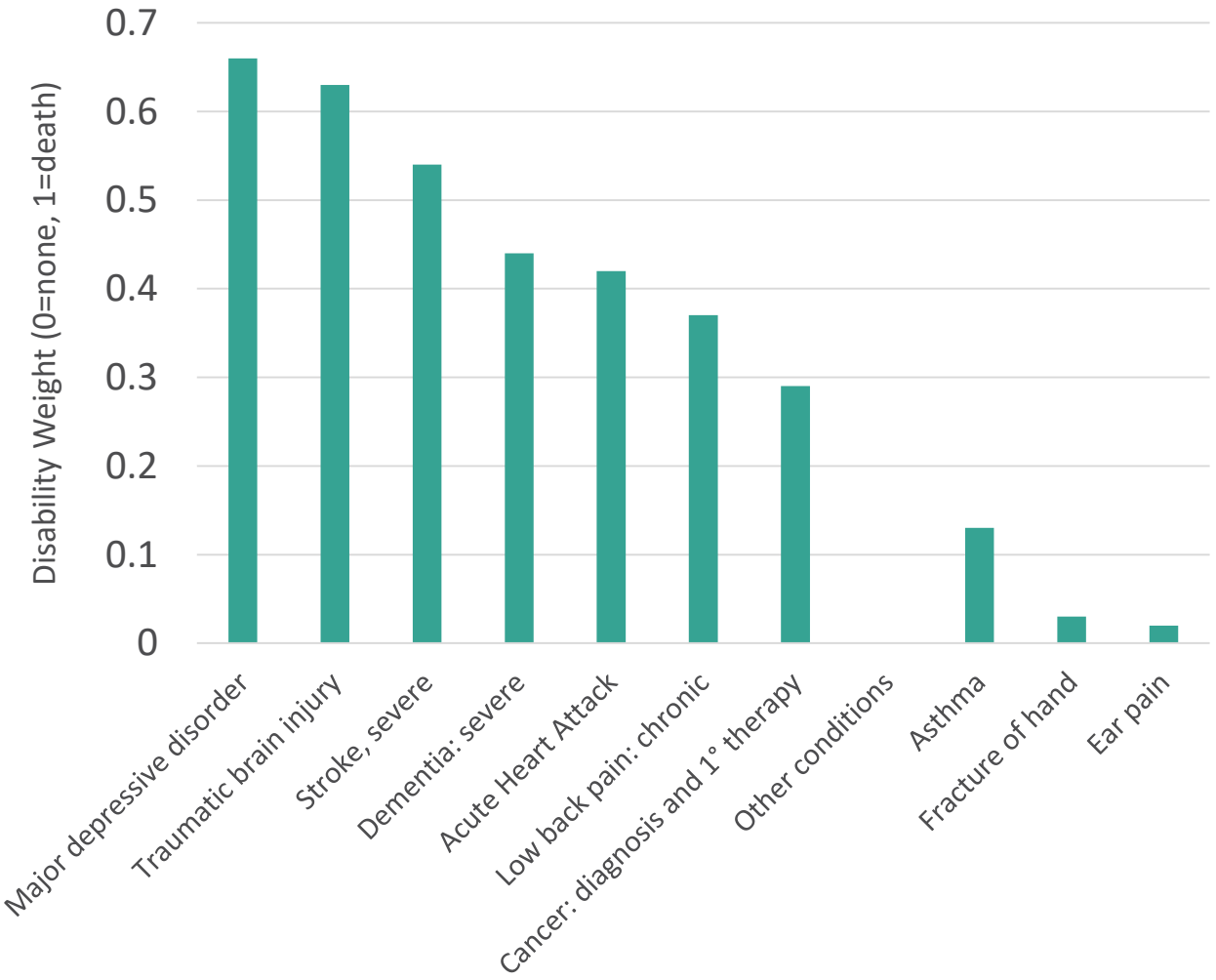
DALYs Due to Premature Death and Disability Combined (YLL+YLD)



- A woman who developed chronic, low back pain at 25 dies prematurely at age 60
- Assuming a disability weight for chronic back pain is 0.37, her loss is:
- Years living with disability + years of life lost

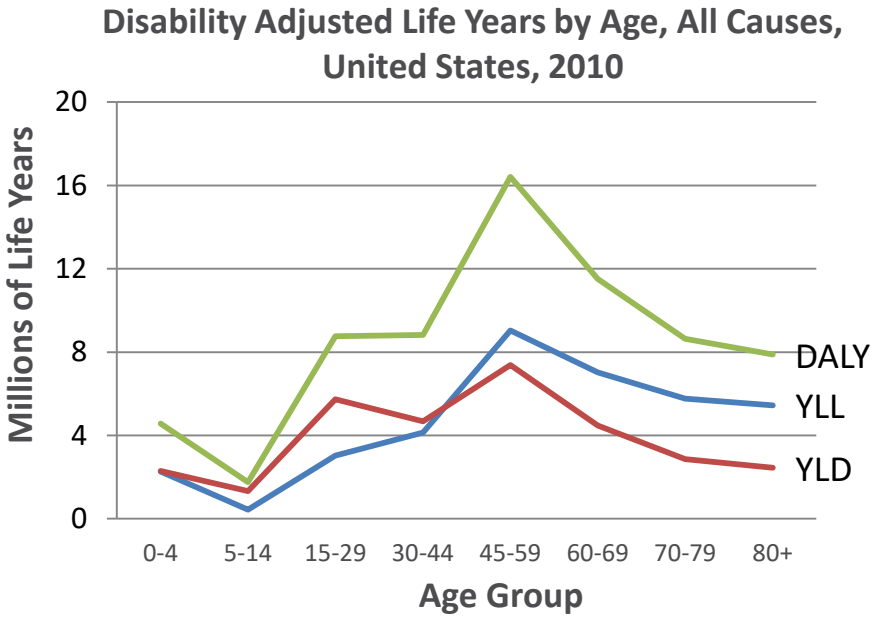
$$(60y\text{-}25y) \times 0.37 + (82.5y - 60y) \times 1.0 = 13 + 22.5 = 35.5\ y$$

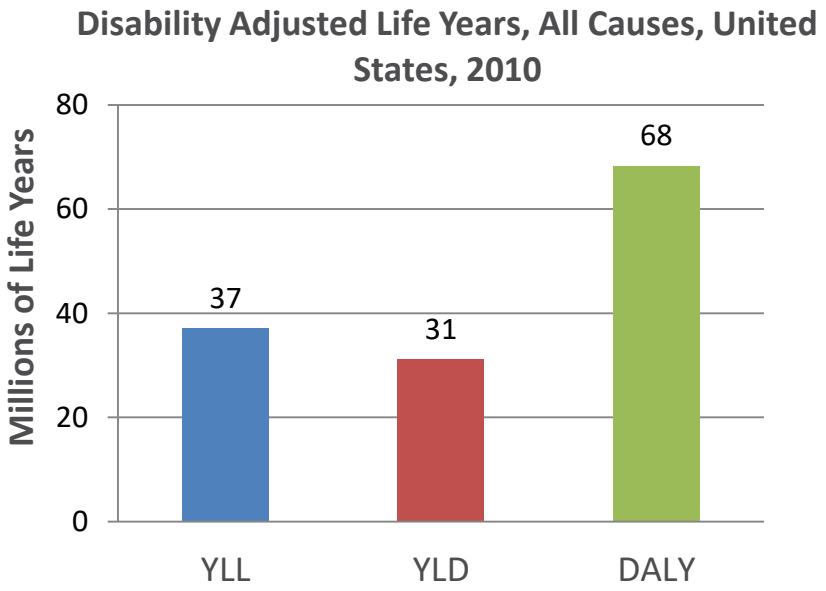
Global Burden of Disease Study Disability Weights for Selected Diagnoses, 2010



DALYS and the Global Burden of Disease Project

- Process repeated for each person in the population
- Since 1996, World Health Organization has calculated DALYs for each country:
  - ✓ 160 specific causes of disease and injuries that correspond to groupings of the International Classification of Diseases (ICD)
  - ✓ Males and females in 8 age groups
  - ✓ Discounted (current years valued more than future years)





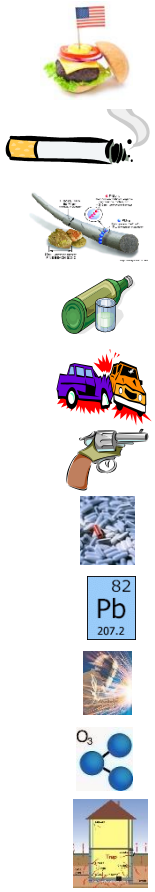
California ITHIM Health Pathways

- Physical Activity
  - Ischemic Heart Disease
  - Hypertensive Heart Disease
  - Stroke
  - Diabetes
  - Dementia (Alzheimer's Disease)
  - Depression
  - Colon Cancer
  - Breast cancer
- Road Traffic Injuries
  - On-public roads, single and multi-party collisions
  - Severe and fatal
- Air pollution
  - Cardio-pulmonary disease, asthma, inflammatory heart disease
  - Acute respiratory diseases in children

Leading Causes of Death, United States, 2014		
	Cause of Death	**N**
	All causes	2,626,418
1.	**Heart disease**	**614,348**
2.	**Cancer**	**591,699**
3.	**Chronic respiratory**	**147,101**
4.	**Unintentional injury**	**136,053**
5.	**Stroke**	**133,103**
6.	**Alzheimer's disease**	**93,541**
7.	**Diabetes mellitus**	**76,488**
8.	Influenza/pneumonia	55,227
9.	Nephritis	48,146
10.	Suicide	42,773

Attributable Fraction of Disease Burden Due to . . .

- What percentage of this disease burden is related to individual risk factors like smoking, alcohol, diet, physical inactivity, violence, etc.?



Causes of Death, 2010	Number	PAF, %
Poor diet and physical inactivity	**665,195**	**25.0**
Tobacco	452,000	17.0
Fine Particulate Matter (PM2.5)	**217,643**	**8.2**
Alcohol consumption	90,000	3.4
Motor vehicles	**33,687**	**1.3**
Firearms	31,672	1.2
Illicit drug use	25,000	0.9
Lead	20,000	0.8
Occupational Risks	12,000	0.5
Ozone	10,882	0.4
Radon, residential	5,000	0.2
Total	1,232,195	46.3

Attributable Fraction of Disease Burden Due to . . .

- How much would the disease/injury burden, BD, change if exposure to the risk factor were eliminated?
  - ✓ $Population\ Attributable\ Fraction = \frac{D_{total} - D_{not\ exposed}}{D_{total}}; \frac{D_{baseline} - D_{alternative}}{D_{baseline}} = 1 - \frac{D_{alternative}}{D_{baseline}} = 1 - RR_{alternative}$

    where D is a disease or injury count or rate
  - ✓ △ BD = BD × PAF
- How much would the disease/injury burden, BD, change if exposure distribution were altered? Aka Comparative Risk Assessment (CRA)
  - ✓ Percent change formula: relative change in exposure(x)-weighted disease risks from baseline distribution, P, to alternative Q:

$$PAF = \frac{\int_{Xmin}^{Xmax} RR(x)P(x)dx - \int_{Xmin}^{Xmax} RR(x)Q(x)dx}{\int_{Xmin}^{Xmax} RR(x)P(x)dx}$$

    RR is the relative risk of the health outcome at a given exposure level, x
    - In ITHIM, for physical activity, exposure, *x*, is the hours per week spent in walking, bicycling, and all other physical activity
    - For air pollution, exposure is the ambient concentration of fine particulate matter ($PM_{2.5}$)
    - For road traffic injuries, exposure is the miles traveled by parties to a collision

Simplified Examples of How ITHIM Works

- Basic Scenario Layout

Annual mean per capita* distances traveled by mode

	Baseline	Scenario	
Mode	Miles	Miles	% VMT
 Walk	100	350	
 Bike	50	250	
 Car-total	7,850	7,400	
Driver	5,888	5,550	-5.7
Passenger	1,963	1,850	
Total	8,000	8,000	

* Total distance traveled divided by total population (i.e. non-walkers included in walk per capita population denominator, non-bikers included in bike per capita population denominator, non-car users included in car per capita population denominator)

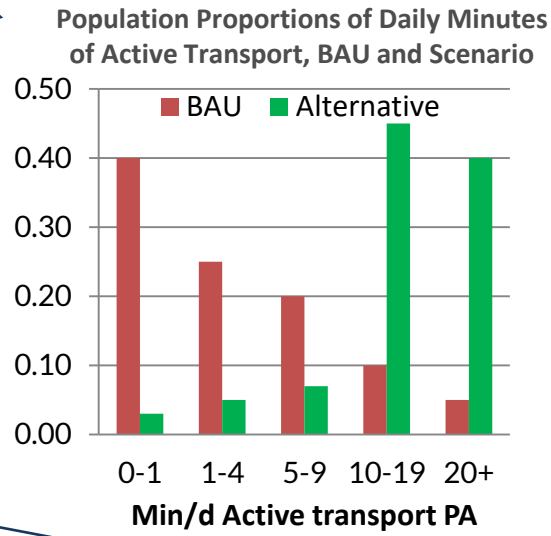
Note: $Absolute\ CO_2\ Reduction = (Per\ capita\ VMT_{baseline} \times Population_{baseline} \times$

Physical Activity: Simplified Example of How ITHIM Works

- Physical Activity (PA) and Ischemic Heart Disease

PA Level (min/d)	Disease Rate (x 10^{-3})	RR	Exposure Distribution	
			BAU	Alternative
0-1	15*	1.00	0.40	0.03
1-4	9	0.60	0.25	0.05
5-9	7	0.47	0.20	0.07
10-19	4	0.27	0.10	0.45
20+	2	0.13	0.05	0.40
Approximate min/d/person PA			5	20
Exposure-weighted disease rate† x 10^{-3}			10.15	3.99
Exposure-weighted RR#			0.677	0.266

* Reference rate for denominator of RR
† BAU (15*0.4 + 9*0.25 + 7*0.2 …) Alt:(15*0.03 + 9*0.05 + 7*0.07…)
# BAU (1.0*0.4 + 0.6*0.25 + 0.47*0.2…) Alt:(1.0*0.03 + 0.6*0.05 + 0.47*0.07…)



$$PAF = \frac{\int_{Xmin}^{Xmax} RR(x)P(x)dx - \int_{Xmin}^{Xmax} RR(x)Q(x)dx}{\int_{Xmin}^{Xmax} RR(x)P(x)dx}$$

- Existing burden of heart disease = 31,854 DALYs
- $PAF = \frac{0.677_{\ baseline} - 0.266_{\ alternative}}{0.677_{baseline}} = \frac{10.15_{\ baseline} - 3.99_{alternative}}{10.15_{baseline}} = 0.607$
- In ITHIM context, sign of PAF is negative: RR = S/B < 1, then sign - (S/B > 1, sign +)
- △ BD = BD × PAF = 31,854 DALYs × -0.607 = -19,332 DALYs
- Burden of Disease reduced (-19,332 DALYs)
- In practice, RRs come from a meta-analysis of the scientific literature

Road Traffic Injury Risk

- Road Traffic Injuries: a mechanistic model based on injuries per miles traveled by the victim (PMT) and the striking vehicle (VMT)

			Number of Injuries/Fatalities					
			Striking Vehicle, SV					
Victim, V			b	p	m	c	d	h
								
Bicycle		b	r_{bb}	r_{bp}	r_{bm}	r_{bc}	r_{bd}	r_{bb}
Pedestrian		p	r_{pb}	r_{pp}	.	.	.	.
Motorcycle		m	r_{mb}	r_{mp}	r_{mm}	.	.	.
Car		c	r_{cb}	etc	.	.	.	.
Bus		d	r_{db}	.	.	.	.	.
Truck		h	r_{hb}	.	.	.	.	.

- Baseline Injury Risk: $R_0 = \frac{Injuries_{Victim0}}{PMT_{Victim0} \times VMT_{StrikingVeh0}}$
- Scenario Injuries: $I_{S1} = R_0 \times PMT_{VictimS1} \times VMT_{StrikingVehS1}$
- Stratified by roadway type and severity (fatal, serious)

Road Traffic Injuries : Example of How ITHIM Works

- Base Scenario Layout

Annual mean per capita distances traveled by mode

Mode		Baseline Miles	Scenario Miles
Walk		100	350
Bike		50	250
Car-total		7,850	7,400
	Driver	5,888	5,550
	Passenger	1,963	1,850
Total		8,000	8,000

- "Safety in Numbers": Observation that pedestrian and bicycle injury rates decline as their trip mode share or distance traveled increases; approximately a square root function

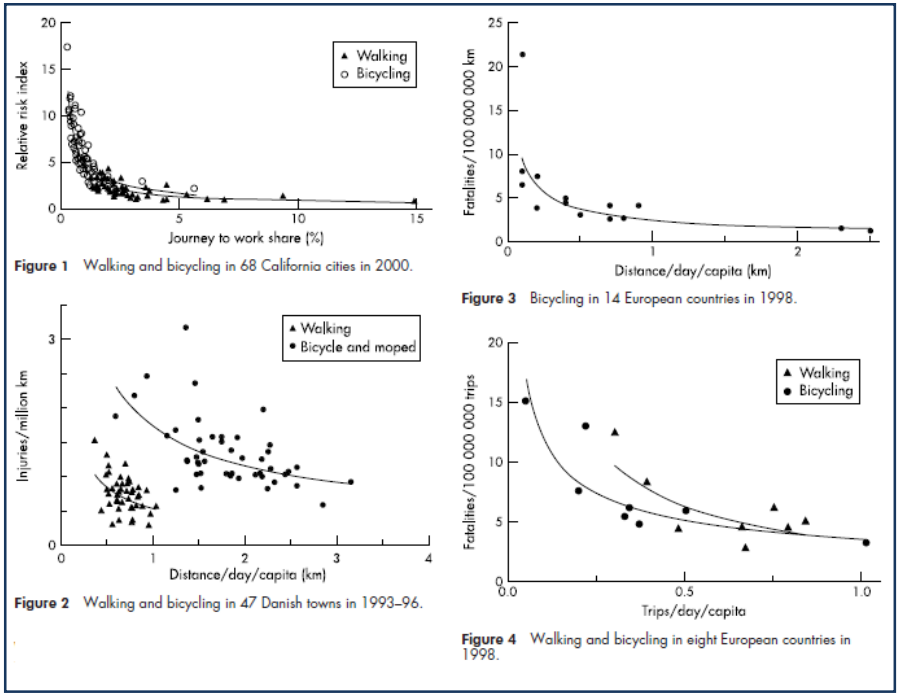


Figure 1 Walking and bicycling in 68 California cities in 2000.

Figure 2 Walking and bicycling in 47 Danish towns in 1993–96.

Figure 3 Bicycling in 14 European countries in 1998.

Figure 4 Walking and bicycling in eight European countries in 1998.

Road Traffic Injuries : Example of How ITHIM Works

Annual mean per capita distances traveled by mode

Mode	Baseline Miles	Scenario Miles
Walk (PMT/VMT)	100	350
Bike (PMT/VMT)	50	250
Car-total (PMT)	7,850	7,400
Driver (VMT)	5,888	5,550
Passenger	1,963	1,850
Total	8,000	8,000

1. Annual Injuries, Baseline (given)

Victim	Striking Vehicle: Bicycle	Striking Vehicle: Car	Total
Pedestrian	5	50	55
Bicycle	6	30	36
Car	0	55	55
Total			146

2. Baseline Rate = injuries/$(PMT*VMT)^{0.5}$

Striking Vehicle: Bicycle	Striking Vehicle: Car
$5/(100*50)^{0.5}$	$50/(100*5887.5)^{0.5}$
$6/(50*50)^{0.5}$	$30/(50*5887.5)^{0.5}$
$0/(7850*50)^{0.5}$	$55/(7850*5887.5)^{0.5}$

3. Baseline Rate

Striking Vehicle: Bicycle	Striking Vehicle: Car
0.070711	0.065163521
0.12	0.055293081
0	0.008090259

4. Scenario Distances

Victim	Striking Vehicle: Bicycle	Striking Vehicle: Car
Pedestrian	$(350*250)^{0.5}$	$(350*5550)^{0.5}$
Bicycle	$(250*250)^{0.5}$	$(250*5550)^{0.5}$
Car	$(7400*250)^{0.5}$	$(7400*5550)^{0.5}$
Total		

×

5. Baseline Rate

Striking Vehicle: Bicycle	Striking Vehicle: Car
0.070711	0.065163521
0.12	0.055293081
0	0.008090259

=

6. Annual Injuries, Scenario

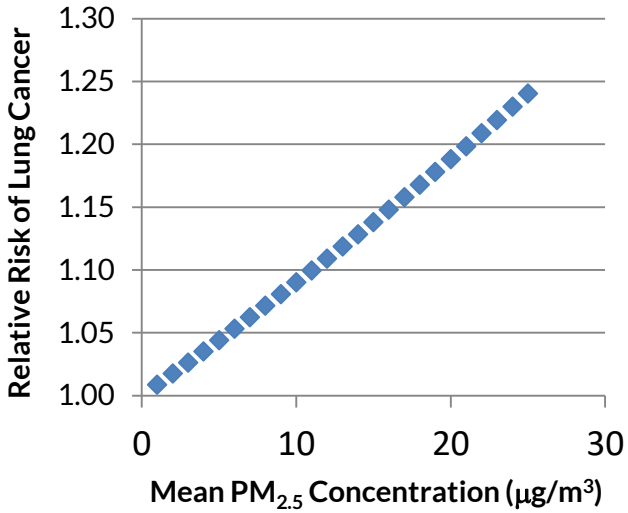
Striking Vehicle: Bicycle	Striking Vehicle: Car	Total
21	91	112
30	65	95
0	52	52
		258

Road Traffic Injuries : Example of How ITHIM Works

- $PAF = \frac{Injuries_{baseline} - Injuries_{scenario}}{Injuries_{baseline}} = \frac{146 - 258}{146} = -0.77$
- In context of ITHIM, PAF = +0.77
- Existing burden of traffic injuries = 10,630 DALYs
- $\triangle$ BD = BD $\times$ PAF = 10,630 DALYs $\times$ 0.77 = 8,185 DALYs
- Burden of Disease increased by 8,185 DALYs

Air Pollution (PM2.5): Example of How ITHIM Works

- Dose-response of lung cancer and $PM_{2.5}$ from literature LN(RR) =0.013103*(b_1- b_0), where b_0 is baseline ambient $PM_{2.5}$ in μg/m^3 and b_1 is scenario $PM_{2.5}$



- Emissions model (e.g. EMFAC2014)
  - ✓ Input assumptions re: car fleet, VMT, year
  - ✓ Output: Tons/day

	Baseline		Scenario	
	Cars	Other Vehicles	Cars	Other Vehicles
PM2.5, tons/d	3.75	3.5	3.54	3.3

- Air shed Model (mobile + stationary sources of emissions)
  - ✓ $PM2.5_{scenario}$ = $PM2.5_{baseline}$ + Change in $PM_{2.5}$ as a function of % change in VMT (-5.7%)
  - ✓ $PM2.5_{scenario}$ = 9.50 + (3.17* △%VMT +0.23)/1000 = 9.48 μg/m^3
  - ✓ Expressed as population-weighted means:

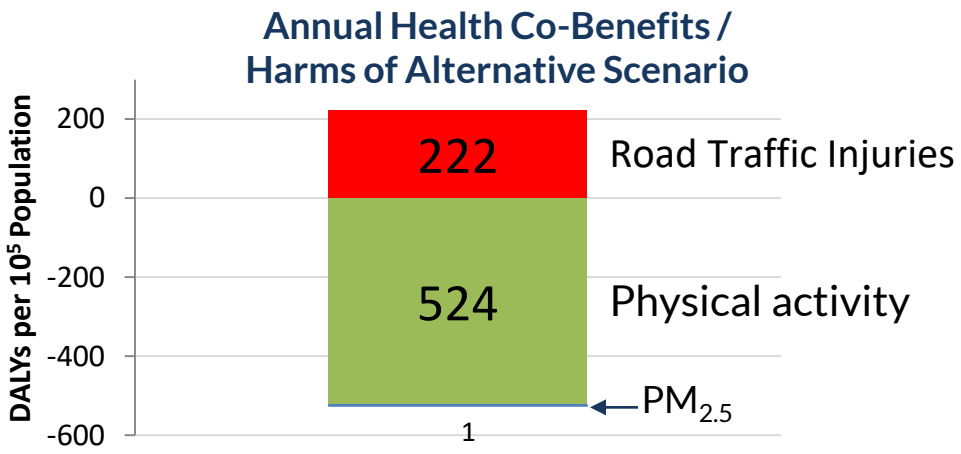
	Baseline	Scenario
$PM_{2.5}$ (μg/m^3)	9.50	9.48

- PAF = 1- $e^{(0.013103 * (9.48-9.50))}$ = 1-0.999738=0.000262
- Existing burden of lung cancer = 17,006 DALYs
- △ BD = BD × PAF = 17,006 × -0.000262 = -4.5 DALYs (BD reduction is -4.5 DALYs)

Synthesizing the Results: Example of How ITHIM Works

Source of Co-Benefit/ Harm	ΔDALYs/y	ΔDALYS per 10^5 population/y
Physical activity	-19,332	-524
Road Traffic Injuries	+8,185	+222
PM2.5	-4.5	< -1
Total	-11,152	-302

* Estimated population$_{2010}$ = 3,690,942



Exercise: Example of How ITHIM Works

- Data on baseline and scenario travel (similar to slide #15), burden of disease, baseline injuries and air shed levels of $PM_{2.5}$ will be presented. Following methods presented in slides 16-22, solve △DALYs for physical activity, injuries, and $PM_{2.5}$ due to shift in travel patterns from baseline to the alternative scenario.

Exercise Organizer

Scenario Layout

Annual per capita mean distances (miles) traveled by mode

Mode	Baseline	Scenario	
Walk	125	425	
Bike	75	375	
Car-total	8,800	8,200	%Δ VMT
Driver	6,600	6,150	-6.8%
Passenger	2,200	2,050	
Total	9,000	9,000	

1. Physical Activity (PA)

PA Level (min/d)	Disease Rate (x 10^{-3})	RR	PA Prevalence by Scenario	
			Baseline	Alternative
0-1	18	1.00	0.50	0.05
1-4	12	0.67	0.30	0.075
5-9	10	0.56	0.10	0.125
10-19	6	0.33	0.07	0.55
20+	4	0.22	0.03	0.20
Overall disease rate				
PAF				
Change in Burden of Disease				

Exercise Organizer

2. Road Traffic Injuries

Annual Injuries, Baseline

Victim	Striking Vehicle		
	Bicycle	Car	Total
Pedestrian	18	65	
Bicycle	22	47	
Car	0	102	
Total	40	214	254

Baseline Rate = injuries/(PMT*VMT)$^{0.5}$

Striking Vehicle	
Bicycle	Car

Scenario Distances$^{0.5}$

Injuries	Striking Vehicle	
Victim	Bicycle	Car
Pedestrian		
Bicycle		
Car		
Total		

Scenario Injuries (Baseline Rate × Scenario Distances$^{0.5}$)

Striking Vehicle		
Bicycle	Car	Total

PAF, (B-S)/B	
Change in Burden of Disease	

Exercise Organizer

3. Air Pollution

Item	Baseline	Scenario
Air shed, μg $PM_{2.5}/m^3$	9.60	
PAF		
Change in Burden of Disease		

$PM_{2.5}$(scenario) = $PM_{2.5}$(baseline) + (3.17* %ΔVMT +0.23)/1000
Coefficient, RR=0.01296

4. Overall Change in Burden of Disease

Disease	DALYs/y	ΔDALYs/y	Rate × 10^5 population* ΔDALYs/y
Heart Disease (PA)	67,686		
Road Traffic Injuries	20,830		
Respiratory Diseases ($PM_{2.5}$)	65,859		
Total	154,375		

* Overall Population = 7,351,177

Implementation of California ITHIM

- Physical activity time is weighted by intensity of energy expenditure, Metabolic Equivalent Task (1kcal/kg/h) based on tabular values of standard tasks (e.g., walking, bicycling at various speeds)
- Repeat calculations for each disease:
  - ✓ Physical Activity: heart disease, stroke, diabetes, dementia, depression, colon cancer, breast cancer
  - ✓ $PM_{2.5}$: cardiopulmonary disease, respiratory diseases, lung cancer, acute respiratory disease in children only
- Physical activity: stratify analyses by sex and age (0-4, 5-14, 15-29, 30-44, 45-59, 60-69,70-79, 80+)
- Road traffic injuries: stratify by injury severity (fatal, serious) and by roadway type (local, arterial, highway)

Strengths of California ITHIM

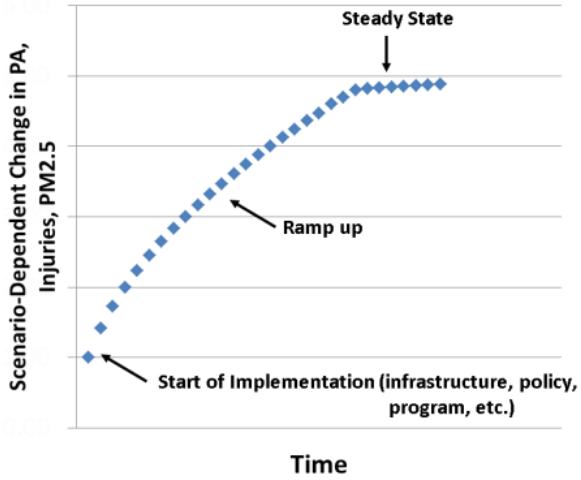
- Health outcomes are credible and definitive (deaths, years of life lost, etc.)
- Established evidence-based relationship between physical activity and health outcomes (synthesis of the 20+ best epidemiologic studies)
- Comparative Risk Assessment methodology has a well-established epidemiologic basis and is part of public health practice
- Disability adjusted life years puts both mortality and morbidity on a common health outcome scale. This avoids the difficulties of pooling deaths, hospitalizations, ER visits and other health outcomes. Takes into account both premature mortality and disability (especially mental health outcomes).

Strengths of ITHIM

- Assumptions incorporate what is empirically observed from scientific literature:
  - ✓ Population distribution of travel-related physical activity is log-normally distributed and variability tends to decrease at higher mode shares
  - ✓ Pedestrian and bicycle injury rates are sensitive to speed-volume of motor vehicles (severity and facility type stratification) and mode share (safety in numbers)
  - ✓ As mode share increases, the demographics (age-sex distribution) of active transport tends to flatten out.
- Free, open source (R/Shiny)
- Extensive documentation on model development, calibration & use
- Extensions of model are available for cost-benefit, equity, and downscaling

Key Assumptions in California ITHIM

- Time
  - ✓ Outcomes occur at user-specified, steady-state time horizon
    - No ramp up period for changes in alternative scenario from baseline/BAU
    - Invariant distribution of baseline non-transport physical activity, $PM_{2.5}$ levels



- Physical Activity
  - ✓ Assumes that increase in physical activity due to active transport is not compensated by a decrease in non-transport physical activity (no activity substitution)

- Road traffic injuries
  - ✓ Safety in numbers: slope of injury rate-mode share relationship is a constant, 0.5 square root. It does not account for technology, infrastructure, policy, education, etc. that further deflects this slope.
- Baseline Multiples, Fixed Time, U Surgeon General, and LCD scenarios have same total per capita mean travel distance as baseline. This is an optional assumption to simplify analysis, but is not required (less travel is OK).

Key Limitations of California ITHIM or Data

- Geographic Scale and Aggregation
  - ✓ Model parameters and outcomes were aggregated by age and sex within geographic areas; heterogeneity within geographic areas and heterogeneity by other covariates are missed
  - ✓ At sub-county geographic levels in urban areas and at county levels in rural areas, data from travel surveys used in model calibration do not provide statistically stable estimates of:
    - Walking and bicycling travel (time and distance) by age and sex
    - Non-transport related physical activity by age and sex
    - VMT of trucks, buses, or rail
  - ✓ Available methods of modeling car emissions and $PM_{2.5}$ were limited to geographically large areas (air basins)

Key Limitations of California ITHIM or Data

- Equity
  - ✓ Neither travel patterns nor burden of disease is broken down by race/ethnicity, income, or other measures of social disadvantage
    - Users must supply a disease-specific, covariate-adjusted data file to make the health outcomes specific to the race/ethnicity, income level, etc. of the equity subgroup
    - User's must supply a data file for scenario travel distances by mode for the equity subgroup

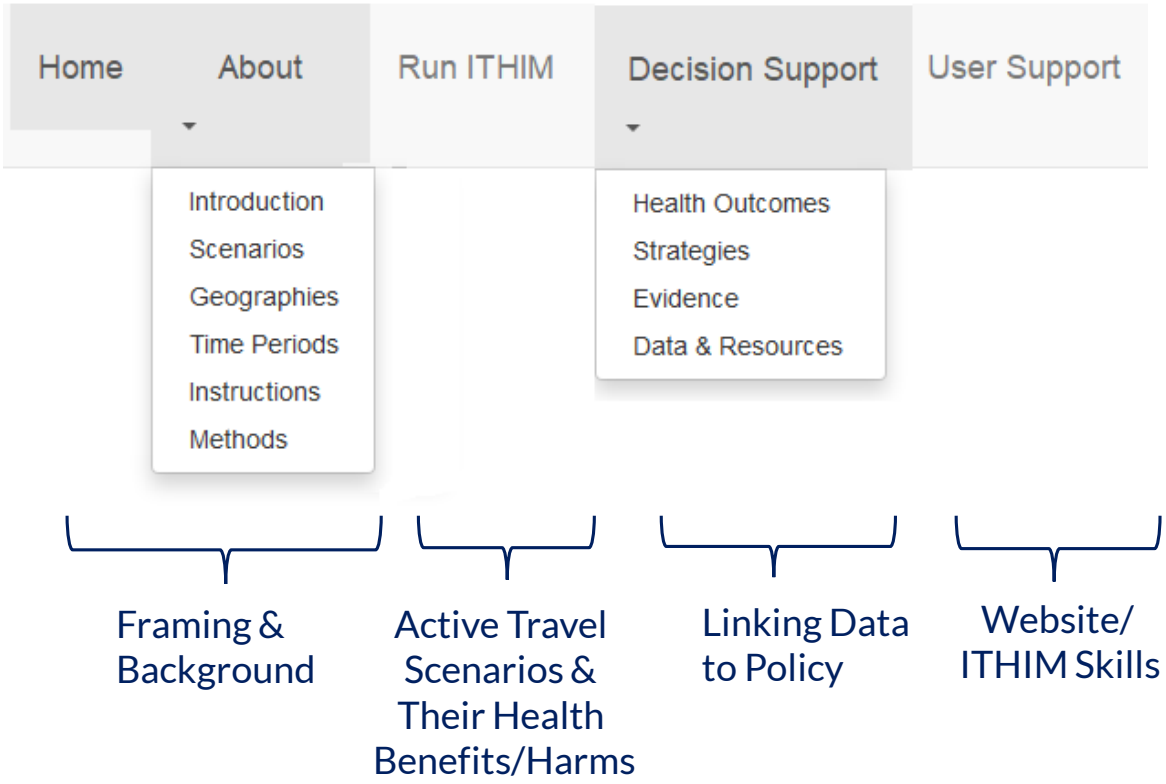
III. Practice: California ITHIM R/Shiny

- Free, open-source application in R/Shiny
  - Web version: http://cal-ithim.org/ithim
    - ✓Designed for desktop computers & popular browsers (IE14, Chrome, Firefox, Edge, Opera, Safari)
    - ✓Not designed for smart phones/tablets
  - Downloadable desktop application at: TBD at https://ww2.arb.ca.gov/
    - ✓Same as web version, but does not need to be connected to Internet
- User's manual & documentation at: https://cal-ithim.org/ithim/#UserSupport
- Replaces spread sheet versions (2011 – 2016)

California ITHIM

https://cal-ithim.org/ithim

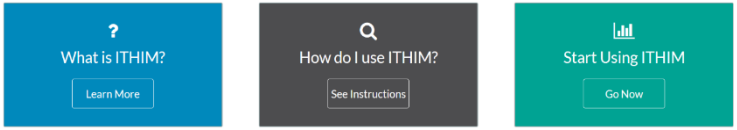
- Organization of the application



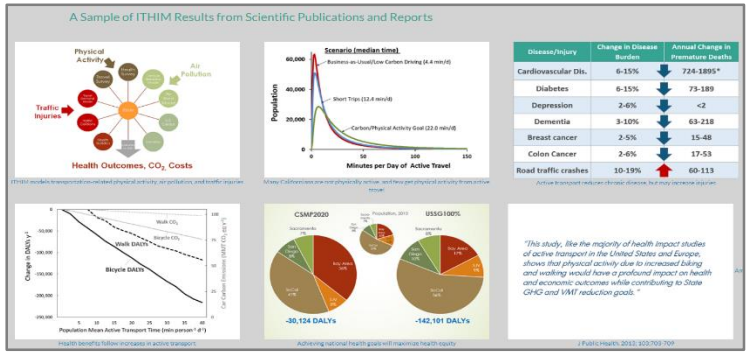
Home Page

Clicking on the action buttons will link you directly to About and the RunITHIM pages.

About > Introduction About > Instructions RunITHIM (Tool Page)



Clicking on the a gallery image will link you to technical reports and scientific publications featuring ITHIM.



About Pages

Menu to navigate between About pages →

- What is California ITHIM?
- How has California ITHIM been used?
- Why is California ITHIM important
- What is the history of California ITHIM?

About > Instructions

Menu to navigate between About pages →

Choosing:

- Scenarios
- Geographies
- Time Periods

About > Scenarios

Menu to navigate between About pages →

Baseline 2010 + 8 Scenarios

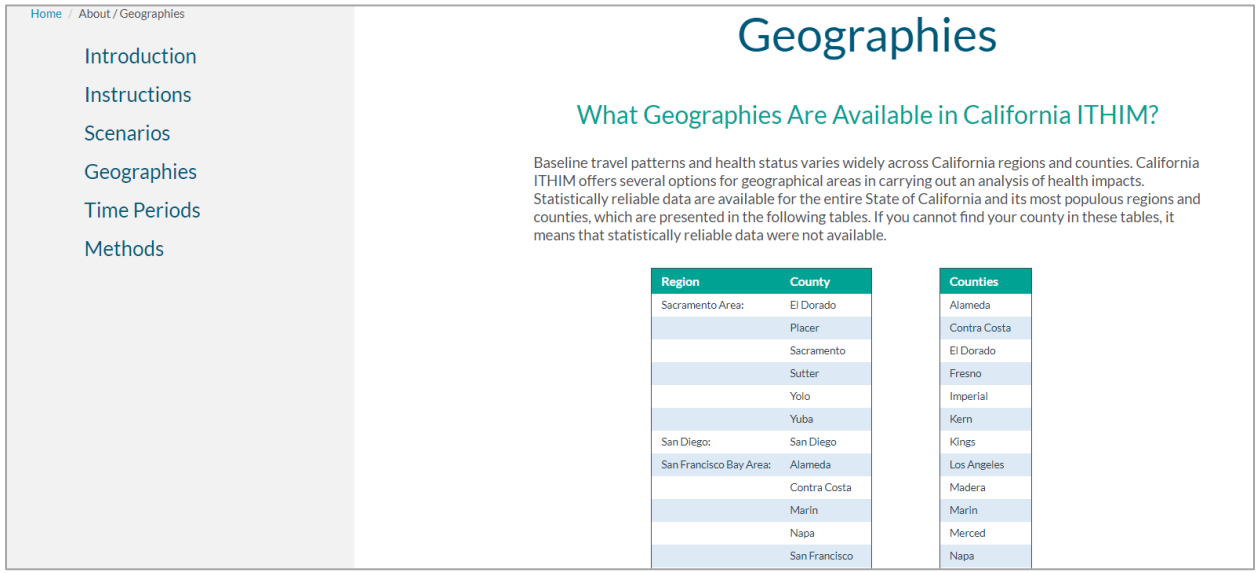
- State Agency Goals
- Health Goals
- "What If"
- User data upload

Scenario Choices

Abbrev.	Scenario Name	Description
Baseline	2010 Baseline	Per capita mean travel times and distances by mode (walk, bike, car, bus, rail, truck, motorcycle) in 2010. Active modes are based on the California Household Travel Survey, 2012, and motorized modes are based on outputs of regional and statewide travel demand models
CARB2030	Air Resources Board 2017 Scoping Plan Update, 2030 Goals	The goal of tripling 2010 baseline levels of walking and transit and increasing those of bicycling by 9-fold by 2030
CSMP2020	CalTrans Strategic Management Plan, 2015-2020, Goals	The goal of doubling 2010 baseline levels of walking and transit and quadrupling those of bicycling by 2030
FixedTime	Fixed Amount of Walking or Cycling Time per Week	User-defined per capita minutes per week of walking and cycling with concomitant reductions in car travel
LCD	Low Carbon Driving	Car travel that reflects a significant increase in electric vehicles, hybrids, and low carbon fuels. No change in total car vehicle miles traveled or baseline levels of active transportation
Muliples	Multiples of the 2010 Baseline for Walking, Cycling, Transit	User-defined multiples of baseline levels of walking, cycling, and transit with concomitant reductions in car travel
Short Trips	Short Car Trips (50%) Replaced by Walking and Cycling	Substituting 50% of short car trips (< 5 miles) by walking and cycling
SCS2040	Sustainable Community Strategies, 2040	Travel patterns of the preferred scenarios in California regions represented by the largest metropolitan planning organizations (SF Bay Area, Sacramento Area, San Joaquin Valley, Southern California, San Diego County)
USSG	U.S. Surgeon General Physical Activity Recommendations	Levels of active transport in the California population in which the typical resident walks 75 minutes per week and bicycles 75 minutes per week with concomitant reductions in car travel
Upload	User Upload	User-defined travel distances and time by mode

About > Geographies

Menu to navigate between About pages →



- Statewide
- Five major regions corresponding to MPO boundaries
- 30 counties within regions (30)

About > Geographies

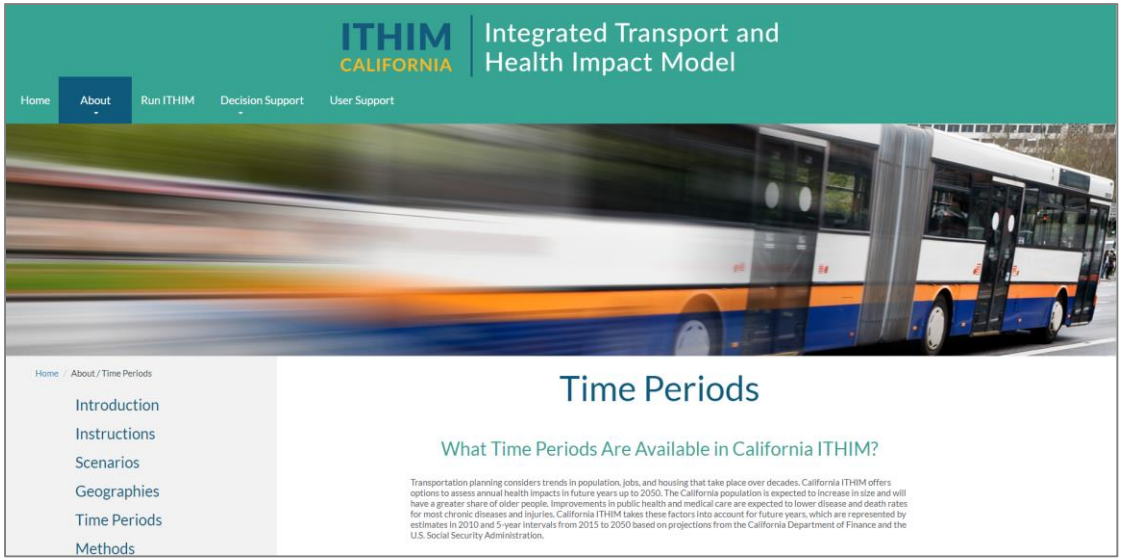
State & Regions
California
Sacramento Area (6 counties)
San Diego County
San Francisco Bay Area (9 counties)
San Joaquin Valley (8 counties)
Southern California (6 counties)

Counties	
Alameda	Sacramento
Contra Costa	San Bernardino
El Dorado	San Diego
Fresno	San Francisco
Imperial	San Joaquin
Kern	San Mateo
Kings	Santa Clara
Los Angeles	Solano
Madera	Sonoma
Marin	Stanislaus
Merced	Sutter
Napa	Tulare
Orange	Ventura
Placer	Yolo
Riverside	Yuba

Note: Statistically reliable data on active transportation not available for other counties

About > Time Periods

Menu to navigate between About pages →



- Users can sync the horizon of the travel scenario with population growth and the trajectory of California's burden of disease, 2010-2054

Time Periods
2010
2015-2019
2020-2024
2025-2029
2030-2034
2035-2039
2040-2044
2045-2049
2050-2054

About > Methods

Menu to navigate between About pages →

- Comparative Risk Assessment and Health Pathways (Physical Activity, PM2.5, Road Traffic Injuries)
- Burden of Disease
- Assumptions
- Limitations: Time, geographic scale

RunITHIM Tool Page

- Tool Page is interactive: once you change an option, the output will change instantly

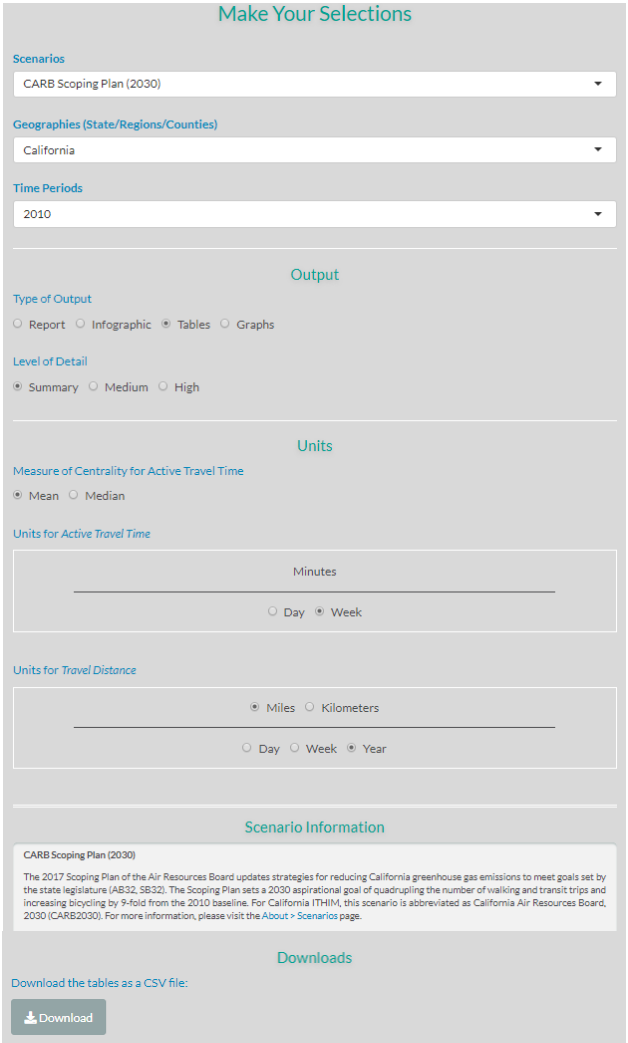
Options Selection ↓ **Output** ↓

Tool Page – Options Selection

1. Scenarios, including user-uploaded data
2. Geographies
3. Time Periods
4. Output Formats

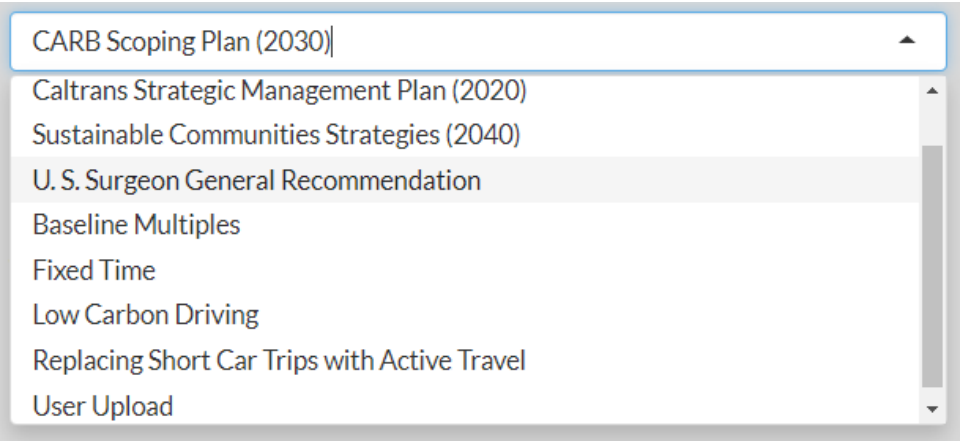
5. Time/distance units

6. Scenario description
7. Downloads
   a. CSV Table data

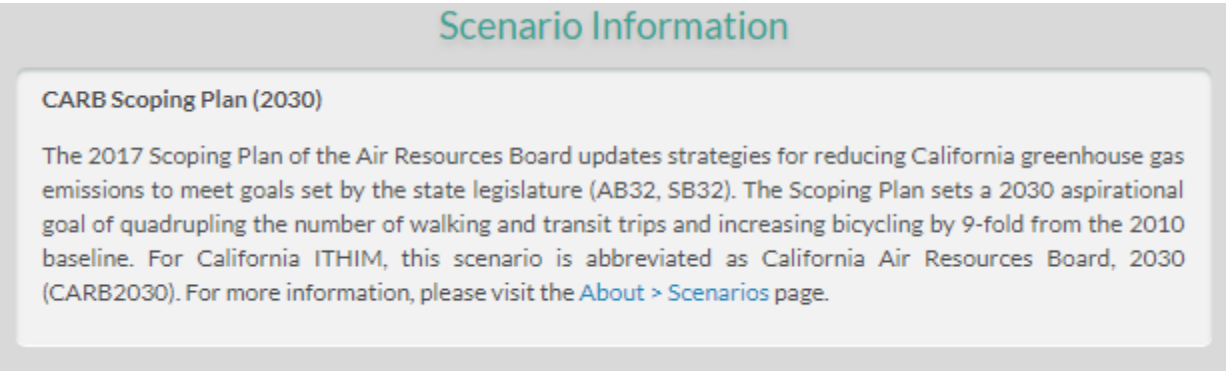


Options Selection: Scenarios

- Use the pick list and scroll bar to select a Scenario



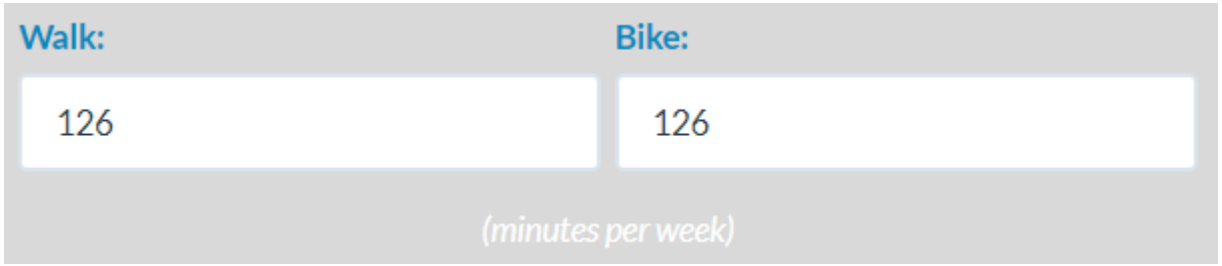
- After selecting a Scenario, its description will appear below in the options panel



Options Selection: Multiples and Fixed Time

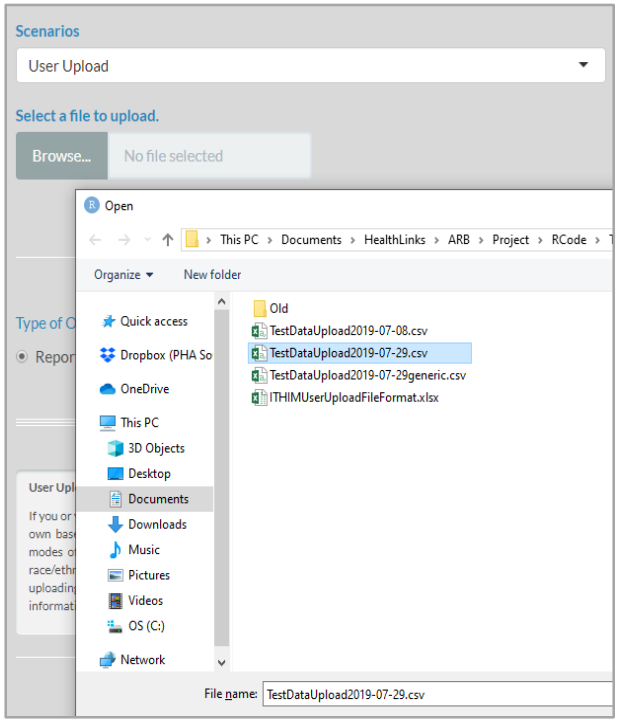
- 'Baseline Multiples' requires user input for relative increase in walking, bicycling, and transit trips
  - ✓ Examples: 2 = 200% or doubling; 1.05 = 5% increase

- 'Fixed Time' requires user input of minutes of active transport per week (range 0 to 126 minutes per week).



Options Selection: User Upload

- Prepare for uploading data to California ITHIM (See User's Manual)
  - ✓ You must have created the upload file a head of time
  - ✓ The upload file must follow a template for format specifications
- Selecting the 'User Upload' scenario, initiates dialogue boxes
  - ✓ Navigate to directory where upload file is located and open



User Upload File Format

VarName	Definition	CodeLevels
Region	California and 5 MPOS regions	California; SF Bay Area; San Joaquin Valley; Sacramento Area; Southern California; San Diego County
Item_Name	Distance Travel by mode or Proportion of Distance by Facility Type	Per Capita Mean Daily Travel Distance or Proportion of Vehicle Miles by Mode and Facility Type
Scenario_ID	User defined alphanumeric string to identify baseline, BAU, or scenario	
Mode	Travel mode	Walk, Bike, CarDriver, CarPassenger, Bus, Rail, Motorcycle, Truck
Strata	Facility Type for item_name Proportion of Vehicle Miles by Mode and Facility Type	local, arterial, highway for bus, car, truck modes only
Item_Result	Per capita mean miles/p/day by mode or proportion of miles traveled	10 decimal digit precision

- Match your region so correct health calibration data will be selected.
- Variable names and coding levels must be exact in name and case!
- Missing data (Item_Result) will be filled with baseline regional average.
- User-defined columns can be added after 'Item_Result'

User Upload File Template

Repeating blocks of 17 rows

Distance by mode

Proportion of distance by facility type and mode

Baseline

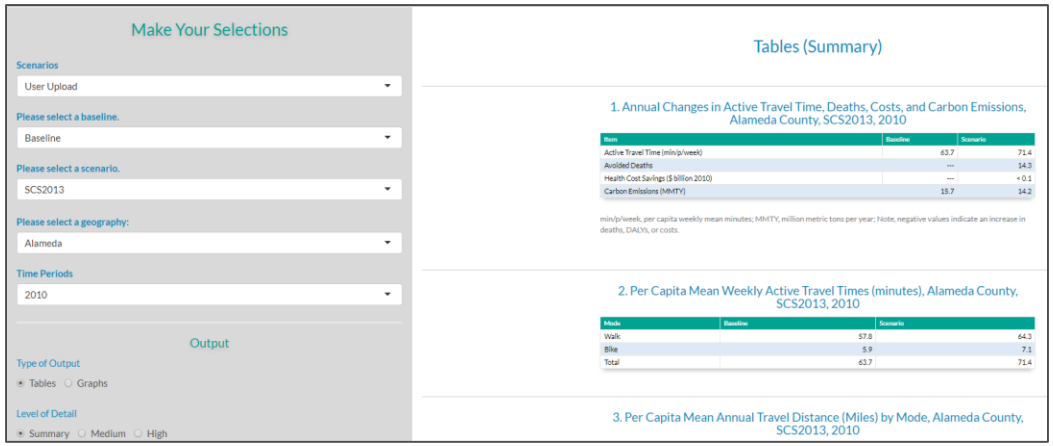
Scenario 1

Scenario$_n$

Region	Item_Name	Scenario_ID	Mode	Strata	Item_Result
SF Bay Area	Per Capita Mean Daily Travel Distance	Baseline	Bike		0.168493151
SF Bay Area	Per Capita Mean Daily Travel Distance	Baseline	Bus		0.804383562
SF Bay Area	Per Capita Mean Daily Travel Distance	Baseline	CarDriver		15.57068493
SF Bay Area	Per Capita Mean Daily Travel Distance	Baseline	CarPassenger		4.997534247
SF Bay Area	Per Capita Mean Daily Travel Distance	Baseline	Motorcycle		0.131232877
SF Bay Area	Per Capita Mean Daily Travel Distance	Baseline	Rail		0.971232877
SF Bay Area	Per Capita Mean Daily Travel Distance	Baseline	Truck		1.854794521
SF Bay Area	Per Capita Mean Daily Travel Distance	Baseline	Walk		0.412876712
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	Baseline	Bus	arterial	0.754691348
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	Baseline	Bus	highway	0.236154249
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	Baseline	Bus	local	0.009154404
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	Baseline	Car	arterial	0.283216159
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	Baseline	Car	highway	0.630440758
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	Baseline	Car	local	0.086343083
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	Baseline	Truck	arterial	0.240165744
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	Baseline	Truck	highway	0.689439711
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	Baseline	Truck	local	0.070394545
SF Bay Area	Per Capita Mean Daily Travel Distance	SCS2013	Bike		0.20109589
SF Bay Area	Per Capita Mean Daily Travel Distance	SCS2013	Bus		1.124931507
SF Bay Area	Per Capita Mean Daily Travel Distance	SCS2013	CarDriver		14.15643836
SF Bay Area	Per Capita Mean Daily Travel Distance	SCS2013	CarPassenger		4.543561644
SF Bay Area	Per Capita Mean Daily Travel Distance	SCS2013	Motorcycle		0.131232877
SF Bay Area	Per Capita Mean Daily Travel Distance	SCS2013	Rail		1.358082192
SF Bay Area	Per Capita Mean Daily Travel Distance	SCS2013	Truck		1.854794521
SF Bay Area	Per Capita Mean Daily Travel Distance	SCS2013	Walk		0.458082192
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	SCS2013	Bus	arterial	0.754691348
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	SCS2013	Bus	highway	0.236154249
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	SCS2013	Bus	local	0.009154404
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	SCS2013	Car	arterial	0.283216159
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	SCS2013	Car	highway	0.630440758
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	SCS2013	Car	local	0.086343083
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	SCS2013	Truck	arterial	0.240165744
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	SCS2013	Truck	highway	0.689439711
SF Bay Area	Proportion of Vehicle Miles by Mode and Facility Type	SCS2013	Truck	local	0.070394545

Options Selection: User Upload

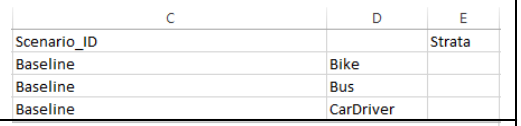
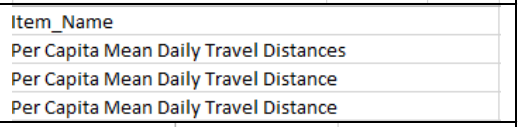
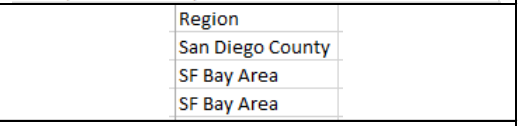
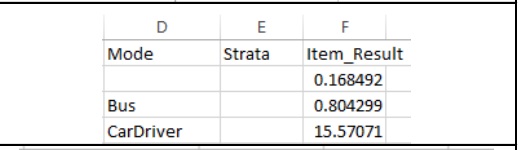
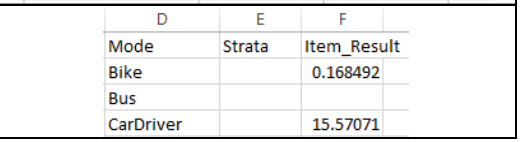
- Tables will automatically populate with default selections
  - ✓ Baseline: in list with “Baseline” or “BAU” string
  - ✓ Scenario: (alphabetically closest to Z)
  - ✓ Year 2010



To change defaults:

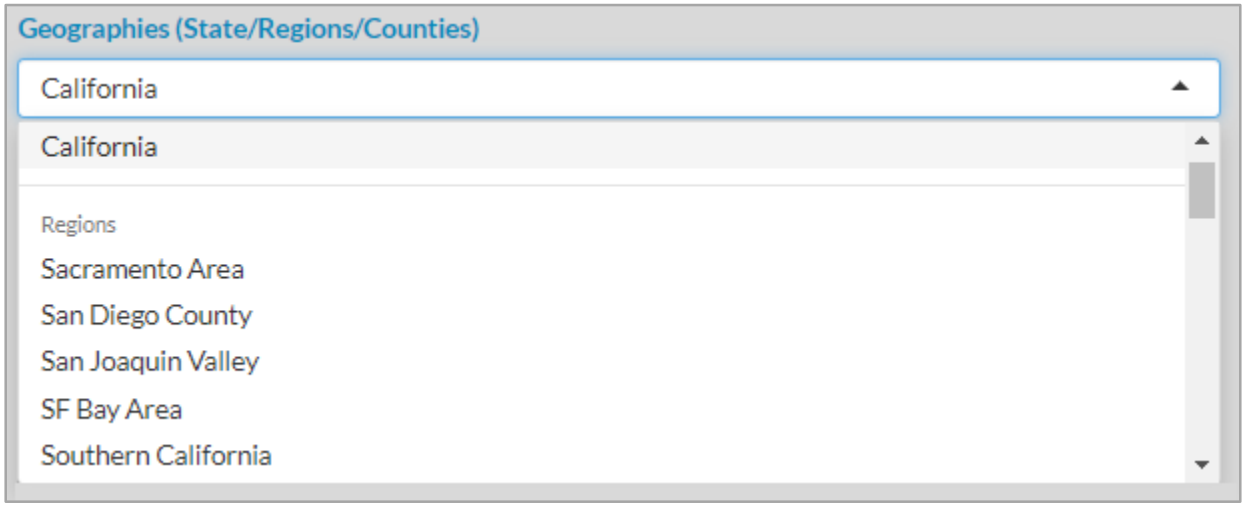
- Select baseline or business-as-usual travel data by selecting its identification number/name in the picklist in ‘Please select a baseline.’
- Select alternative scenario travel data by selecting its identification number/name in the picklist in ‘Please select a scenario.’

User Upload Data Quality: Errors and Warnings

Type of Error/Warning	Example Warning Message	Data File
Column headings	User Error: Headers are incorrect. Missing Mode.	
Item_Name	User Error: Missing "Per Capita Mean Daily Travel Distance" for Baseline in user uploaded data (csv).	
Region (misspell/ missing)	User Error: The Scenario_ID "Baseline" has either a missing Region value, or contains multiple values in Region.csv).	
Mode duplicated/ missing	User Error: The Scenario_ID "Baseline" has an excess or missing "Mode" in Distances in user uploaded data (csv)."	
Item_Result missing (or missing row)	User Error: The Scenario_ID "Baseline" is missing or duplicating mode: Bike.	
Missing motorcycle/bus	Warning: The Scenario_ID "Baseline" is missing values for mode: Bus. Thus, substituting values from ITHIM TOOL's Baseline 2010.	

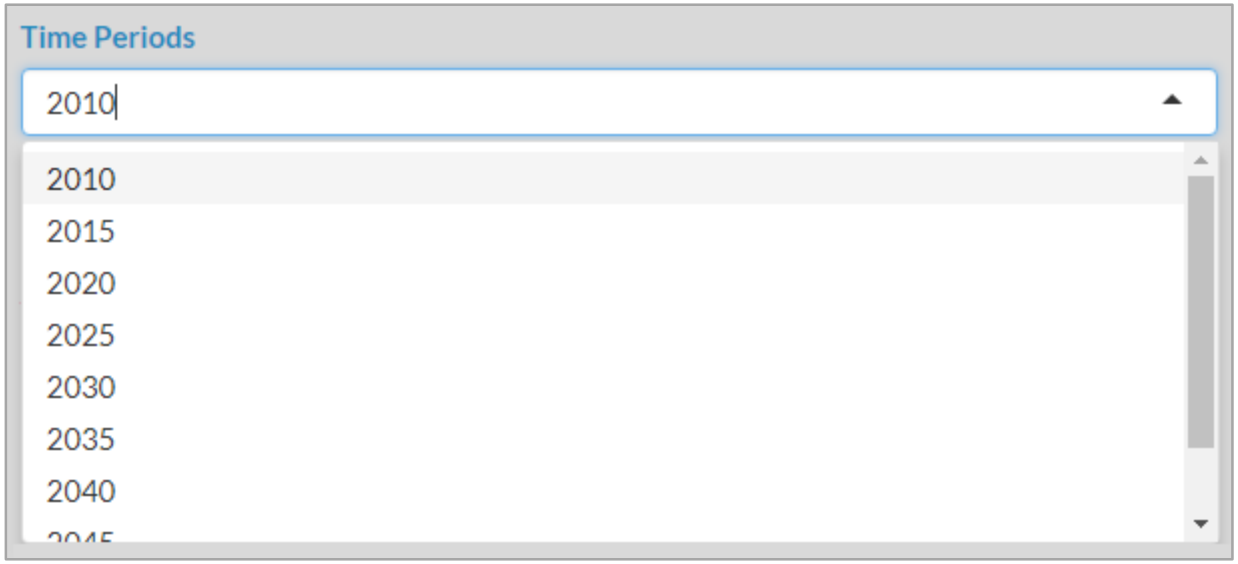
Options Selection: Geographies

- Use the pick list and scroll bar to select a geography
  - ✓ California
  - ✓ Regions
  - ✓ Individual counties within regions (N= 30)

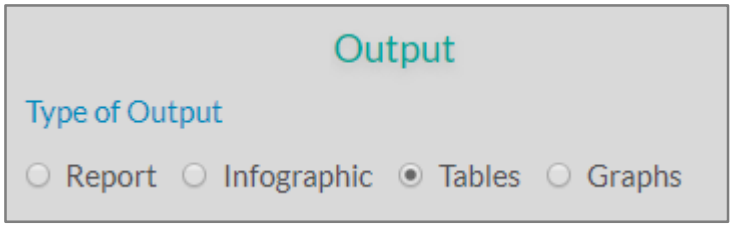


Options Selection: Time Periods

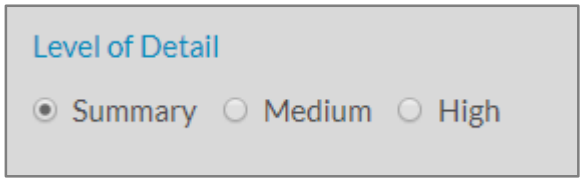
- Use the pick list and scroll bar to select a time period
  - ✓ The time periods are in 5-year intervals (e.g., 2015 = 2015-2019)



Options Selection: Output formats



- Report in format of "Elevator Pitch"
- Infographic – colorful, vertical scrolling story of images, narrative, and numbers comparing the health and carbon impacts of your scenario with "Low Carbon Driving" and "U.S. Surgeon General" scenarios – optimizing carbon reductions and health benefits, respectively
- Tables and graphs:
  - ✓ Select level of detail



Output Examples: Report "Elevator Pitch"

SUMMARY

Replacing short car trips with walking and cycling increases physical activity, which reduces the risks of chronic disease. Walking, cycling, and transit also reduce tailpipe pollution from cars. Lower pollution reduces chronic disease and the health impacts of climate-warming gases. Scenarios that emphasize bicycling generate the greatest amount of health benefit from physical activity. Measures to protect pedestrians and cyclists will maximize health benefits.

In the **CARB2030** Scenario, the typical **California** resident replaces short car trips by increasing current levels of weekly walking and cycling from **64** to **71** minutes.

Due to increased physical activity from active travel, the ITHIM model predicts **59** fewer chronic disease deaths annually.

Less car driving would improve air quality and prevent **15** additional deaths annually.

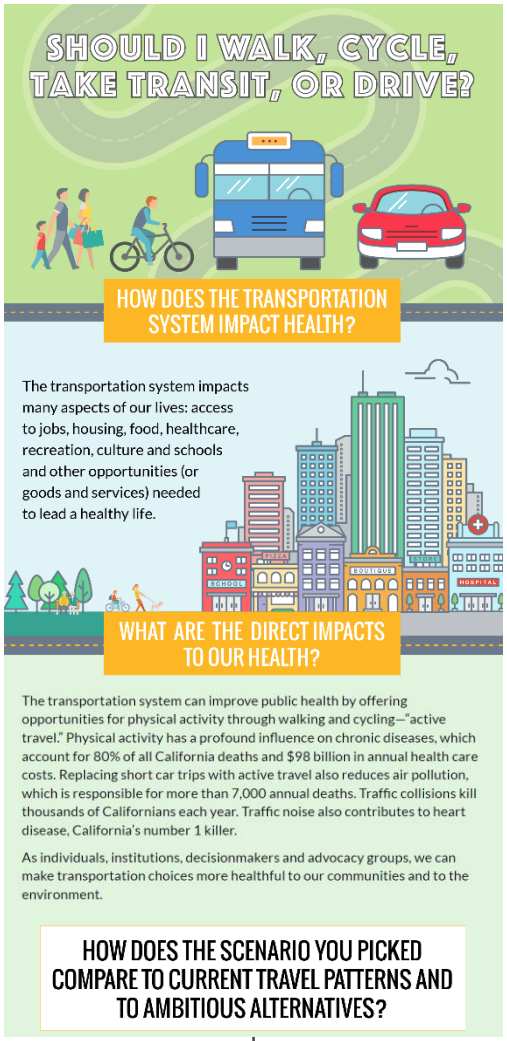
Without additional safety improvements, ITHIM predicts an annual increase of **3** fatal injuries to pedestrians and cyclists.

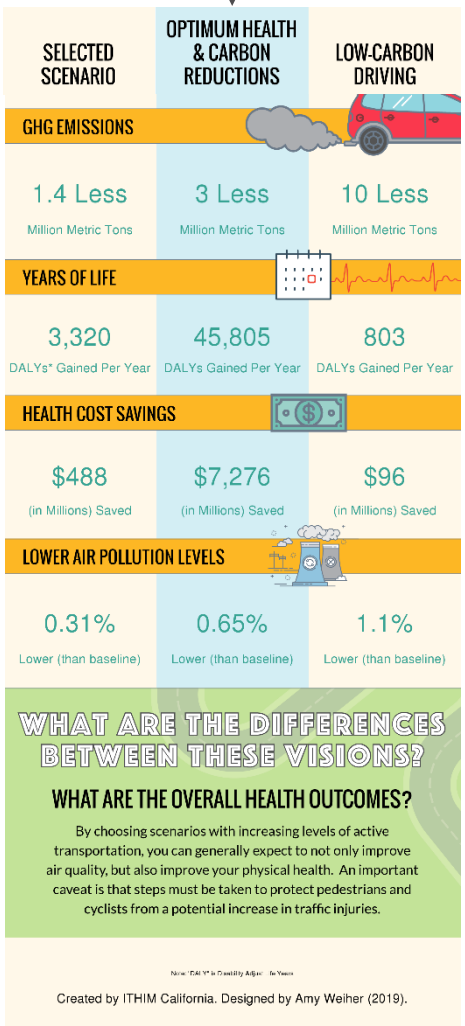
Based on standard cost evaluation methods, the projected annual health benefit gains are between $ **174** million and $ **550** million.

Replacing short car trips with walking, cycling, and transit would also reduce annual car carbon emissions from **16** to **14** million metric tons (MMT).

More Information

Output Examples: Infographic





Output Examples: Tables & Graphs

Annual Changes in Active Travel Time, Deaths, Costs, and Carbon Emissions, California , CARB2030

Item	Baseline	Scenario
Active Travel Time (min/p/w)	63.7	71.4
Avoided Deaths	---	86.0
Health Cost Savings ($ billion 2010)	---	0.2
Carbon Emissions (MMTY)	15.7	14.2

Per Capita Mean Weekly Active Travel Times (minutes), California , CARB2030

Mode	Baseline	Scenario
Walk	57.8	64.3
Bike	5.9	7.1
Total	63.7	71.4

Per Capita Mean Annual Travel Distance (miles) by Mode, California , CARB2030

Mode	Baseline	Scenario
Active	212.2	240.6
Car	7507.4	6825.4
Transit	648.0	906.3
Total (incl. Truck & Motorcyle)	9092.7	8697.4

Annual Change in the Burden of Disease by Health Pathway, California , CARB2030

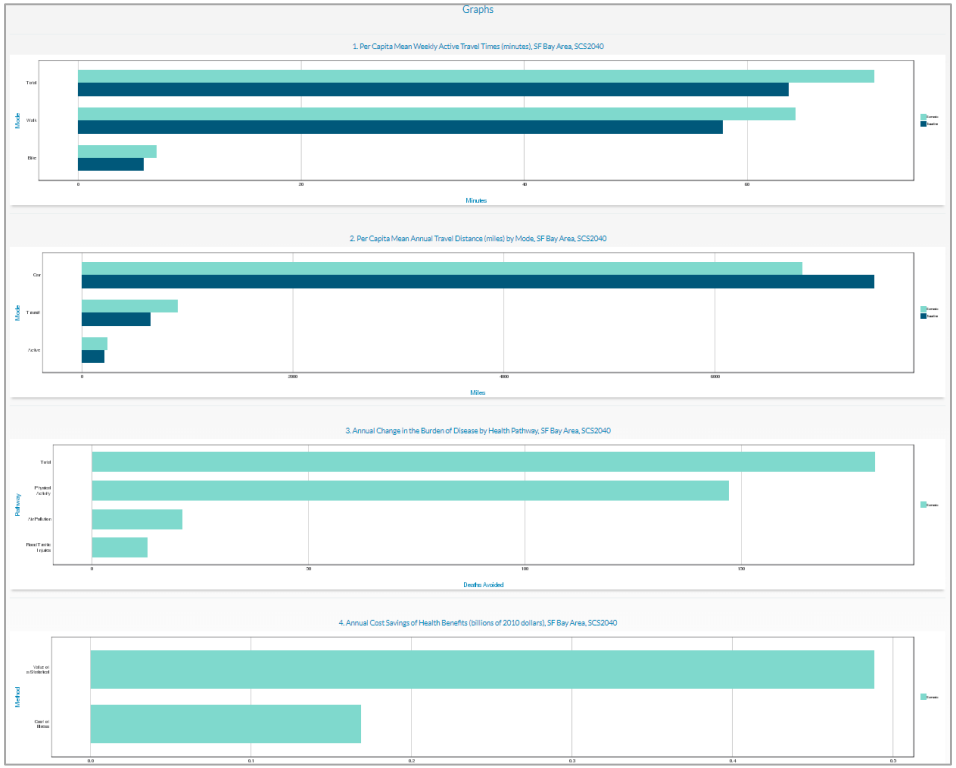
Pathway	PAF.Deaths	Deaths.Avoided	PAF.Dalys	Dalys.Avoided
Physical Activity	0.3	58.6	0.4	1443.4
Air Pollution	0.1	14.5	0.1	193.0
Road Traffic Injuries	2.8	12.8	2.8	657.3
Total	0.3	86.0	2.8	2293.7

Annual Cost Savings of Health Benefits (billions of 2010 dollars), California , CARB2030

Method	Dollars
Cost of Illness	0.2
Value of a Statistical Life	0.5

Annual Car Carbon Emissions, California , CARB2030

CO2.Emissions	Baseline	Scenario
Aggregate (Million Metric Tons)	15.7	14.2
Per Capita (Metric Tons)	2.2	2.0



Output Examples: Units for Outputs

- Active travel
  - ✓ Mean minutes
  - ✓ Median minutes
  - California ITHIM describes <u>population</u> travel patterns, not a single individual.
  - Median more accurate, but may be harder to explain
  - ✓ Minutes per day
  - ✓ Minutes per week
- Distances
  - ✓ Miles (or km) per day
  - ✓ Miles (or km) per week
  - ✓ Miles (or km) per year

Output Formats: CSV

- Follow dialogue box instructions to rename and save file to a folder on your desktop computer
- CSV file has this format:

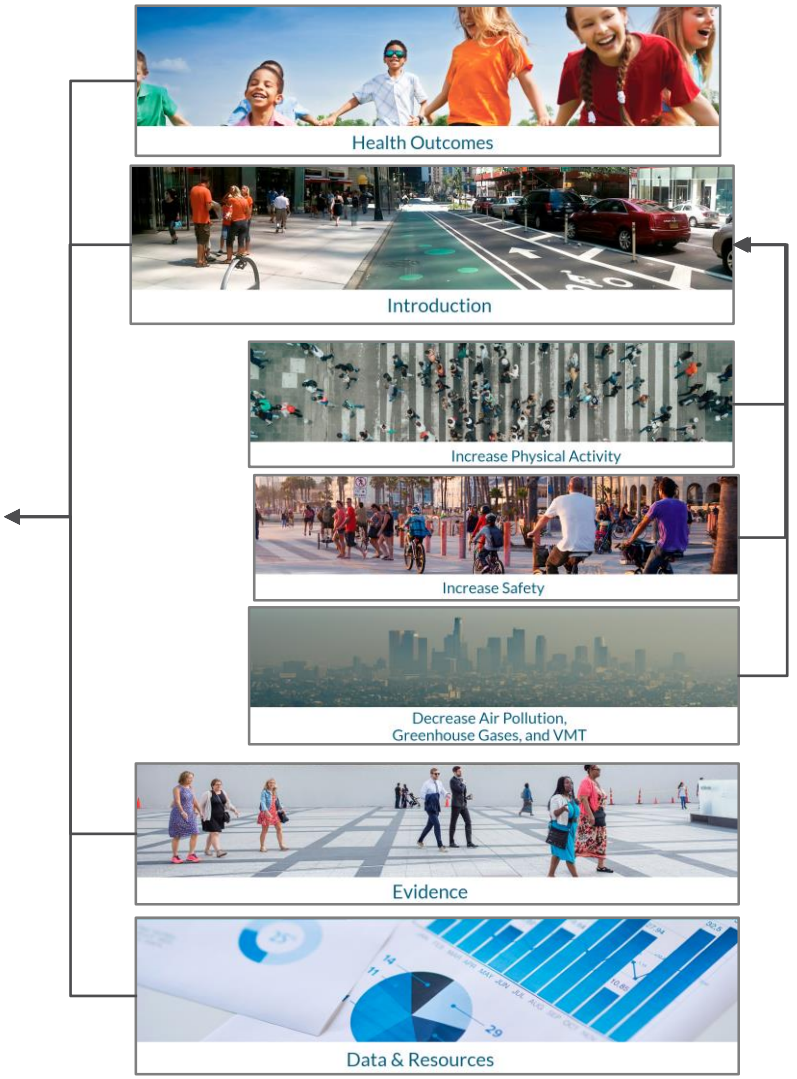
Baseline	Scenario	Level of Detail	Geography	Evaluation Year	Today's Date	Table Title	Row Item Name	Table Values			
baseline	scenario	detail_level	geography	time_period	date_generated	table	a	b	c	d	e
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Annual Changes in Active Travel Time, Deaths, Costs, and Carbon Emissions	Item	Baseline	Scenario		
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Annual Changes in Active Travel Time, Deaths, Costs, and Carbon Emissions	Active Travel Time (min/p/week)	40.57	180.91		
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Annual Changes in Active Travel Time, Deaths, Costs, and Carbon Emissions	Avoided Deaths	NA	5776.72		
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Annual Changes in Active Travel Time, Deaths, Costs, and Carbon Emissions	Health Cost Savings ($ billion 2010)	NA	6.43		
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Annual Changes in Active Travel Time, Deaths, Costs, and Carbon Emissions	Carbon Emissions (MMTY)	94.56	76.98		
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Per Capita Mean Weekly Active Travel Times (minutes)	Mode	Baseline	Scenario		
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Per Capita Mean Weekly Active Travel Times (minutes)	Walk	36.95	148.21		
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Per Capita Mean Weekly Active Travel Times (minutes)	Bike	3.63	32.70		
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Per Capita Mean Weekly Active Travel Times (minutes)	Total	40.57	180.91		
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Per Capita Mean Annual Travel Distance (Miles) by Mode	Mode	Baseline	Scenario		
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Per Capita Mean Annual Travel Distance (Miles) by Mode	Active	334.44	1526.68		
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Per Capita Mean Annual Travel Distance (Miles) by Mode	Car	10349.00	8424.96		
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Per Capita Mean Annual Travel Distance (Miles) by Mode	Transit	181.71	624.49		
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Per Capita Mean Annual Travel Distance (Miles) by Mode	Total (incl. Truck & Motorcycle)	11626.58	11626.58		
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Annual Change in the Burden of Disease by Health Pathway	Pathway	PAF.Deaths	Deaths.Avoided	PAF.Dalys	Dalys.Avoided
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Annual Change in the Burden of Disease by Health Pathway	Physical Activity	6.86	6019.13	6.64	118645.13
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Annual Change in the Burden of Disease by Health Pathway	Air Pollution	0.02	16.96	0.02	232.66
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Annual Change in the Burden of Disease by Health Pathway	Road Traffic Injuries	-8.58	-258.51	-8.58	-14390.29
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Annual Change in the Burden of Disease by Health Pathway	Total	3.34	5777.59	3.06	104487.50
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Annual Cost Savings of Health Benefits (billions of 2010 dollars)	Method	Dollars			
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Annual Cost Savings of Health Benefits (billions of 2010 dollars)	Cost of Illness	6.43			
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Annual Cost Savings of Health Benefits (billions of 2010 dollars)	Value of a Statistical Life	42.74			
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Annual Car Carbon Emissions	CO2 Emissions	Baseline	Scenario		
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Annual Car Carbon Emissions	Aggregate (Million Metric Tons)	94.56	76.98		
Baseline 2010	CARB Scoping Plan (2030)	Summary	California	2010	9/19/2019	Annual Car Carbon Emissions	Per Capita (Metric Tons)	2.73	2.23		

Saving Outputs: PDF, Word, Excel

- Printing the current webpage from your browser
  - ✓ In browser tool bar, select Print or <Ctrl> + P
    - Hard copy to a printer
    - Print to pdf file
- Summary Report
  - ✓ Highlight icons and text, then cut-and-paste into a Word document, which will format as a Word table you can edit
- Infographic
  - ✓ Right click on image, and "Save image as . . ." to a desktop .png file
- Tables
  - ✓ Highlight table(s) with titles and footnotes, and cut-and-paste into a Word or Excel file. HTML5 formatting should be preserved.
- Graphs
  - ✓ Right click on image, and "Save image as . . ." to a desktop .png file
  - ✓ Copy the title separately

Decision Support Pages

1. Health Outcomes
   - Magnitude, health inequities, costs (PA, RTI, $PM_{2.5}$, noise, birth)
2. Strategies to achieve health benefits & CO_2 mitigation via "Policies, Systems, Environmental Change"
   - Increase Physical Activity
     - ✓ Transportation
     - ✓ Land Use
   - Increase Safety
   - Decrease Air Pollution, GHGs, VMT
3. Evidence (for Strategies)
4. Data & Resources



Health Outcomes

- Chronic disease as driver of overall health status
- Contribution to California health burden by:
  - ✓ Physical inactivity
  - ✓ Air pollution
  - ✓ Road traffic injuries
- Health inequities (race/ethnicity, income, urban/rural)
- Costs

Examples of Policies, Systems, Environmental Change

- Policies
  - California Legislation and Governmental Programs
  - Complete Streets
  - Health in All Policies
  - Street Users Hierarchy
- Systems Changes
  - Speed limits and enforcement (speed, DUI, distracted driving)
  - Expansion of transit routes/transit system interconnectivity
  - Vision Zero (multi-sectoral systems approach to roadway safety)
  - Education and incentives
- Environmental Changes
  - Infrastructure for walking, cycling, and transit
  - Built environment interventions that favor residential & employment density/balance, diversity of land uses, destination accessibility, design of the roadway network, distance to transit)

Sources for Health Outcomes and Strategies

- 42 scientific reviews & articles
- Transportation-Related Health Outcomes
  - ✓ CDPH data on chronic diseases associated with physical inactivity and traffic injuries
  - ✓ Physical Activity Guidelines Committee, 2018 (PA)
- Health Equity
  - ✓ CDPH mortality data (PA)
  - ✓ American Public Health Association, Safe Routes to School National Partnership, Vision Zero.org, and American League of Bicyclists (RTI)
  - ✓ Union of Concerned Scientists (Traffic-Related $PM_{2.5}$)

Sources for Evidence

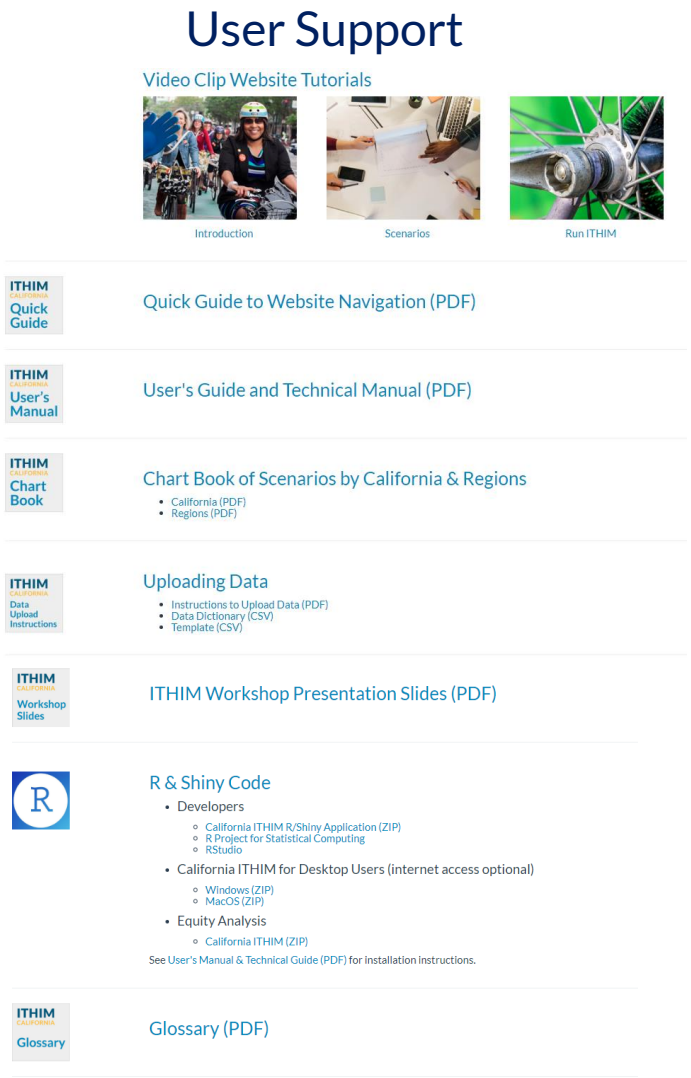
- Physical Activity: Transportation Infrastructure & Land use
  - Community Preventive Services Taskforce, 2014
- $PM_{2.5}$: California Air Resources Board, 2018
- RTI: Safety Countermeasures that Work
  - National Highway Traffic Safety Administration, 2015;
  - National Transportation Safety Board, 2017
  - Crash Modification Factors Database, 2018
- VMT reduction strategies
  - National Center for Sustainable Transportation/UCD, 2017

Data & Resources

- California ITHIM Data Sources
  - CHTS, California Household Travel Survey, 2012
  - CHIS, California Health Interview Survey, 2009
  - SWITRS, Statewide Integrated Incident Reporting System, 2011-2015
  - GBD, Global Burden of Disease, 2013
  - CDPH, California Department of Public Health
  - EMFAC, Emissions Factor Model 2017
  - CARB, Incidence Per Ton of Emissions
- California legislation & agencies (ARB, SGC, CDPH, UCB/SAFETREC)
- Infrastructure/built environment design
  - NACTO, LEED, FHWA - Design
- National Bike/Ped educational nonprofits
- Indicator projects
  - Healthy Places Index (Public Health Alliance of Southern California)
  - CalEnviroScreen (California Environmental Protection Agency)
  - Transportation and Health Tool (USDOT)

User Support Materials

- Video Clip Demos (mp4, 5-7 min)
- Quick Guide (pdf, 2p)
- User's Manual (pdf, 132p)
- Chart books: California and regional (pdf, 136p)
- Instructions/file template for uploading data (pdf/csv)
- ITHIM workshop slides (pdf, 69p)
- ITHIM/TDM interface code for MPOs
- Shiny/R Code (.R in zip file)
- Glossary (pdf, 1p)



Credits

- University of California, Davis:
  Neil Maizlish, PhD (*namaizlish@ucdavis.edu)*
  Kenji Tomari, MS (*ktomari@ucdavis.edu*)
  Jonathan London, PhD (*jklondon@ucdavis.edu)*
  Sarah Grajdura, MS *(sagrajdura@ucdavis.edu)* with support from the Nico Linesch Legacy Fund
- Consultants
  Amy Weiher (*amy@weihercreative.com)*
  Cheng Sheng Jiang, PhD (*cjiang89@umd.edu*)
  Linda Rudolph, MD (*Linda.Rudolph@phi.org)*
- California Air Resources Board
  Cynthia Garcia, MS (cynthia.garcia@arb.ca.gov)
- Project funded by California Air Resources Board (17RD025)