Smart and Healthy Transportation Systems – VIP Project Progress Report Fall 2023

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Project Overview - Objectives

- **Long-term vision:** develop a systematic health impact assessment model that would allow DVRPC to incorporate health considerations into their long-range planning activities and other agency analysis.

- **Year-1 objective:** develop a roadmap to systematic health impact assessments for transportation systems, serving as a guide for Drexel and DVRPC to continue research activities in subsequent years.

Project Overview – Year 1 Plan

1 Pathway

Identify pathways through which transportation system affects public health

2 Model

Review existing health impact models for transportation systems (e.g., ITHIM, HEAT)

3 Quantification

Investigate metrics to quantify the health impact through each pathway

4 Roadmap

Develop a roadmap to health impact assessment for transportation systems

Project Overview – Progress to Date

Spring 2023

Pathway

Identify pathways through which transportation system affects public health

1

2

Model

Review existing health impact models for transportation systems (e.g., ITHIM, HEAT)

Quantification

Investigate metrics to quantify the health impact through each pathway

3

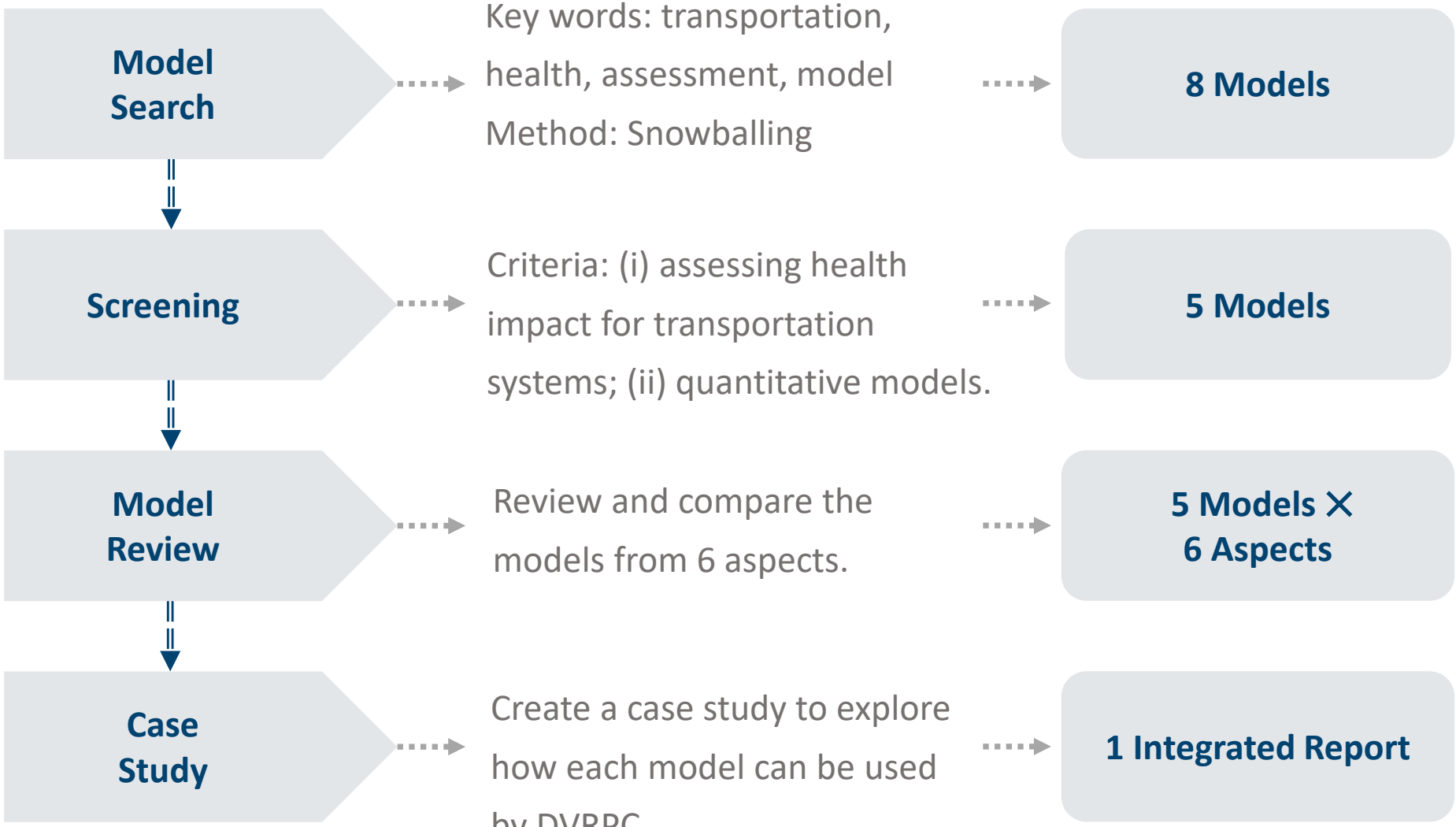
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Roadmap

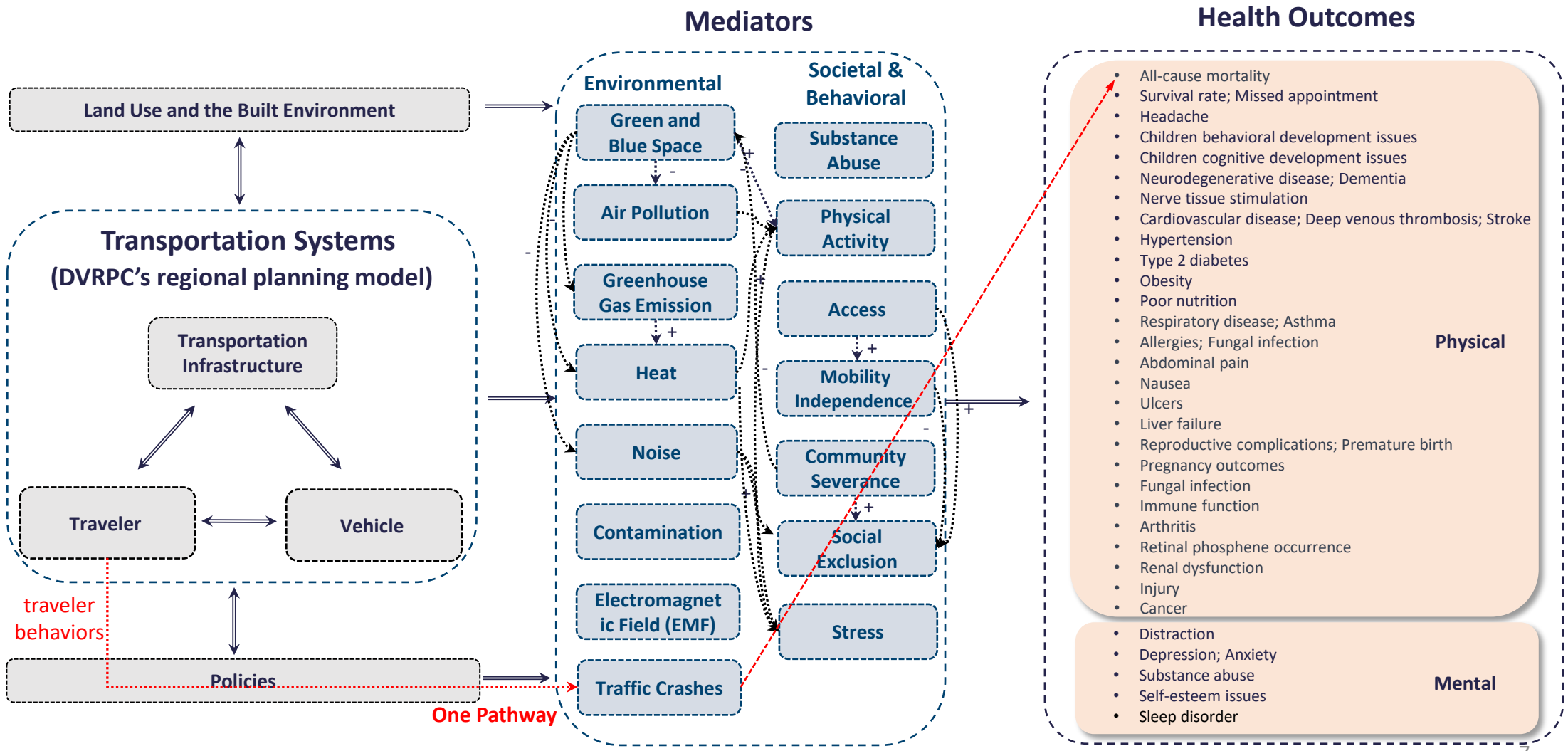
Develop a roadmap to health impact assessment for transportation systems

Fall 2023

Methods


Model Search
Key words: transportation, health, assessment, model
Method: Snowballing
8 Models
Screening
Criteria: (i) assessing health impact for transportation systems; (ii) quantitative models.
5 Models
Model Review
Review and compare the models from 6 aspects.
5 Models ✕ 6 Aspects
Case Study
Create a case study to explore how each model can be used by DVRPC.
1 Integrated Report

Recap – Overview of Pathways



Results – Model Overview

Model	Creator
Health Economic Assessment Tool (HEAT)	World Health Organization
Integrated Transport and Health Impact Model (ITHIM)	Cambridge University
Health-Oriented Transportation (HOT) Model	University of Wisconsin
Urban and TranspOrt Planning Health Impact Assessment (UTOPHIA)	Natalie Mueller et al.
National Public Health Assessment Model (N-PHAM)	Urban Design 4 Health

Results – Model Overview

- All models have only considered a subset of pathways linking several mediators to select health outcomes.
  - Physical activity, air pollution, & traffic crashes frequently modelled.
  - All-cause mortality - the most common health outcome.
- All models are developed using data collected from certain geographic units. Their transferability needs to be examined.
  - HEAT uses country level data.
  - N-PHAM uses health and travel survey data in California.
- Many assumptions are made in each model.
  - HEAT uses linear dose-response function.

Case Study – Scenario

- Question: What would be the health impacts if we doubled cycling time in 2050 in the Greater Philadelphia region? $v_{t,bike} = 2v_{b,bike}$

	Baseline	Target (Future)
Vehicle Miles Travelled (VMT) for mode j	d_{bj} (e.g., $\mathrm{d}_{b,bike}$)	d_{tj} (e.g., $\mathrm{d}_{\mathrm{t},bike}$)
Person Miles Travelled (PMT) for mode j	p_{bj} (e.g., $p_{b,bike}$)	p_{tj} (e.g., $p_{t,bike}$)
Travel time for mode j	v_{bj} (e.g., $v_{b,bike}$)	v_{tj} (e.g., $v_{t,bike}$)
Total travel-related PA time per year	$v_b = v_{b,bike} + v_{b,walk}$	$v_t = v_{t,bike} + v_{t,walk}$
Other travel-related PA info	location, purpose, mode	location, purpose, mode

Case Study – HEAT

- Mediator: Physical Activity (PA)

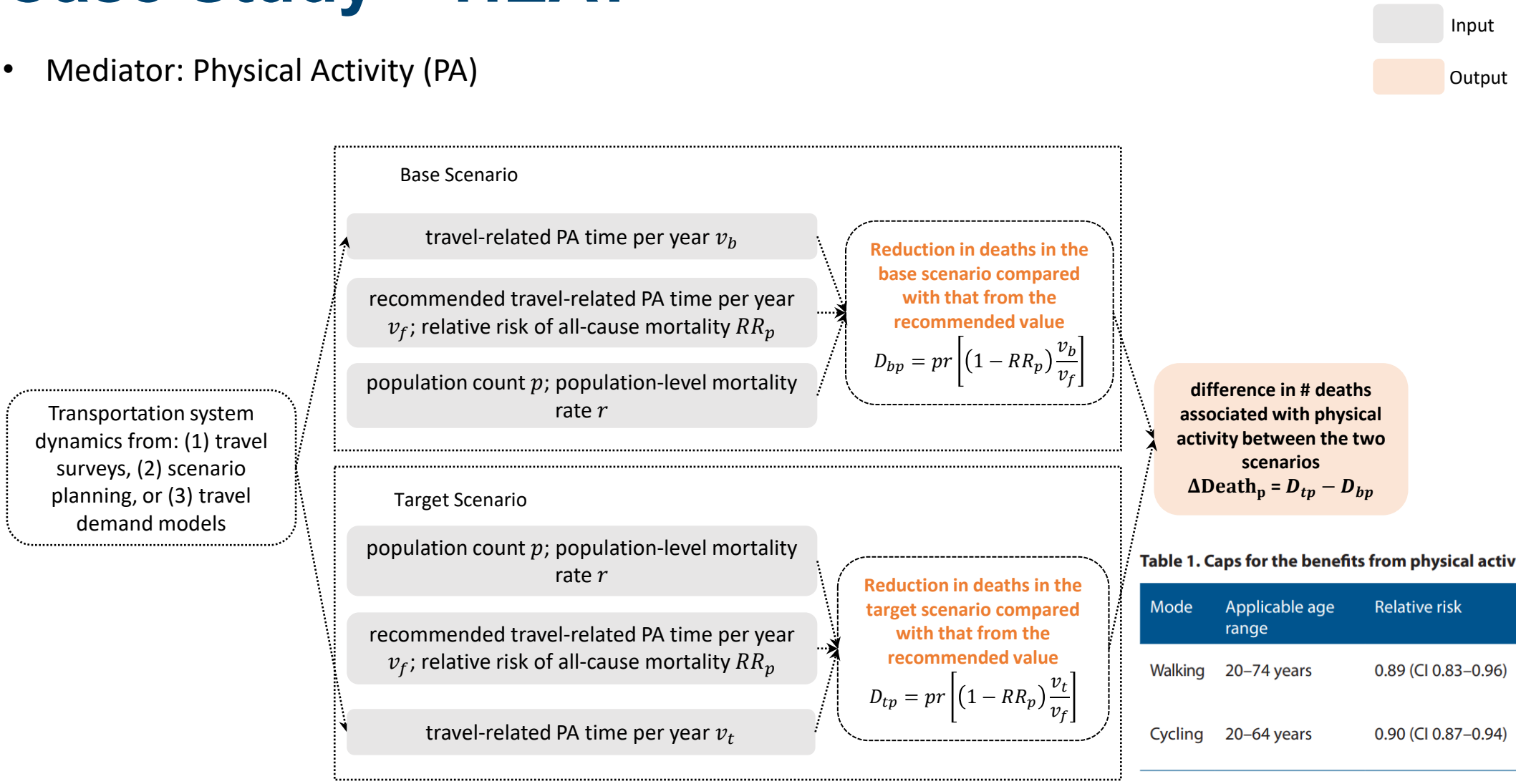
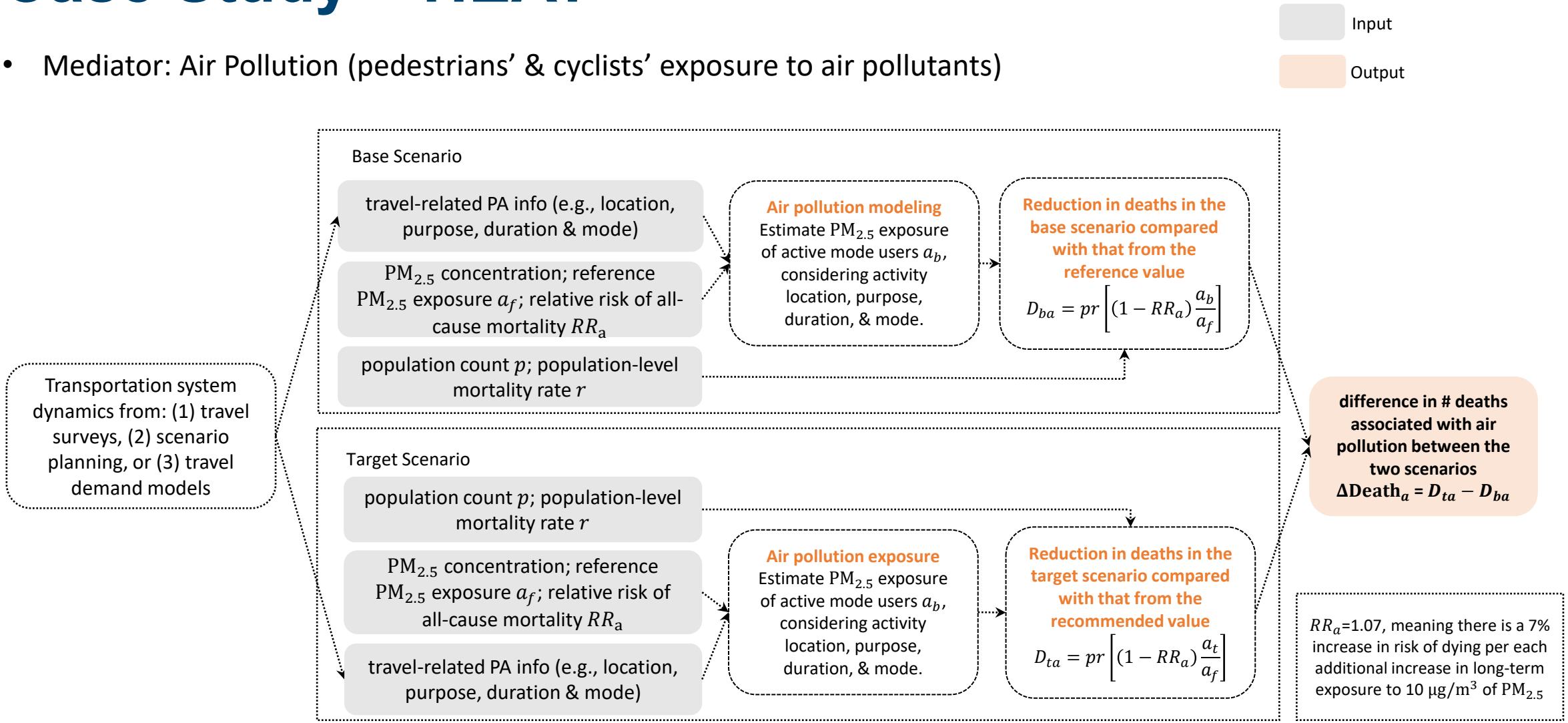


Table 1. Caps for the benefits from physical activity in HEAT

Mode	Applicable age range	Relative risk	Reference volume
Walking	20–74 years	0.89 (CI 0.83–0.96)	168 minutes/week
Cycling	20–64 years	0.90 (CI 0.87–0.94)	100 minutes/week

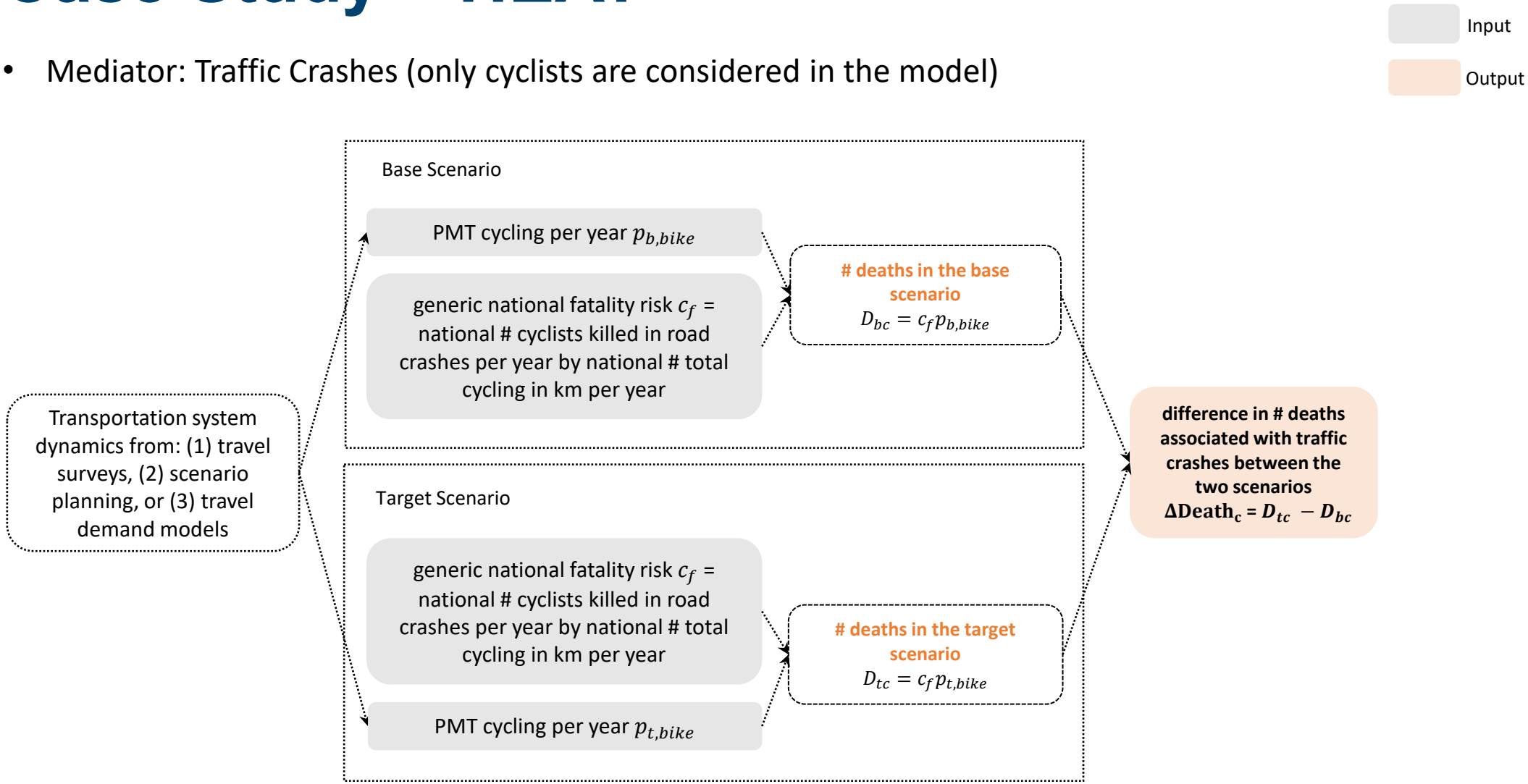
Case Study – HEAT

- Mediator: Air Pollution (pedestrians' & cyclists' exposure to air pollutants)



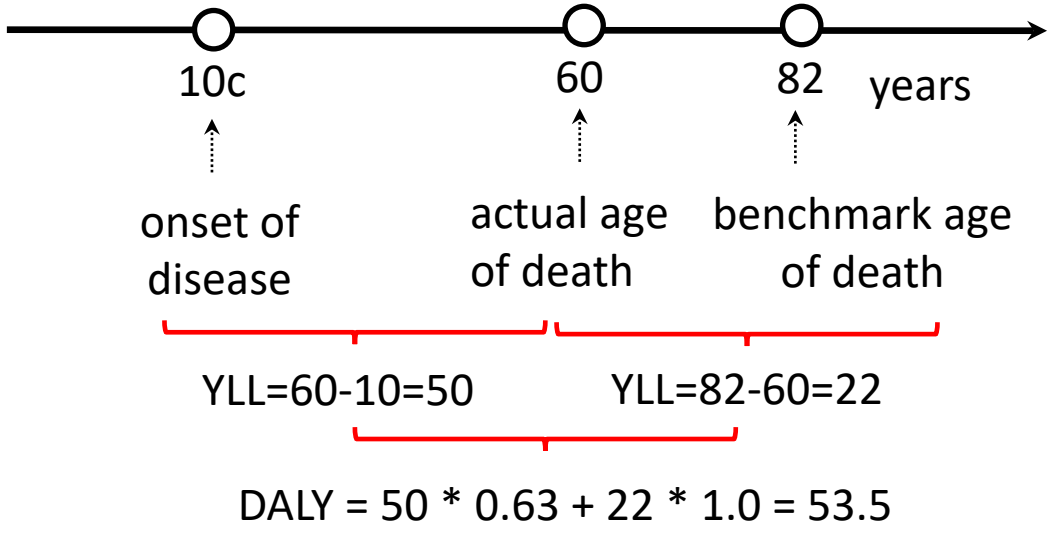
Case Study – HEAT

- Mediator: Traffic Crashes (only cyclists are considered in the model)



Case Study – ITHIM

- Preliminary: Burden of Disease; the metric adopted in ITHIM to quantify health outcomes



Life expectancy (benchmark age of death): # years lived without getting ill before dying

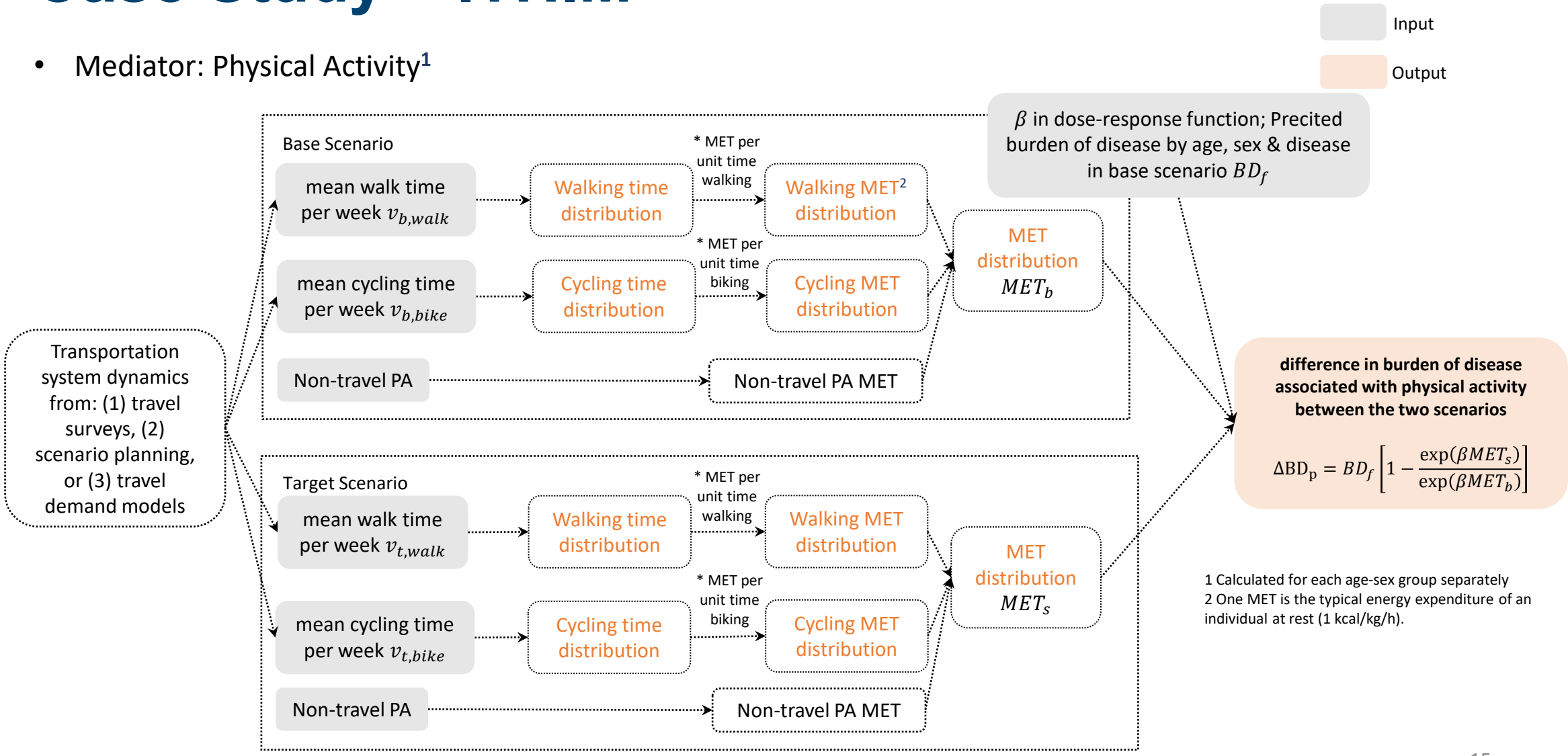
Years of Life Lost (YLL): # years between the benchmark and actual age of death

Years of Living with Disability (YLD): # years between the actual age of death and the age of onset of a disabling disease or injury

Disability Adjusted Life Years (DALY): weighted sum of YLL and YLD, which is how the burden of disease is measured

Case Study – ITHIM

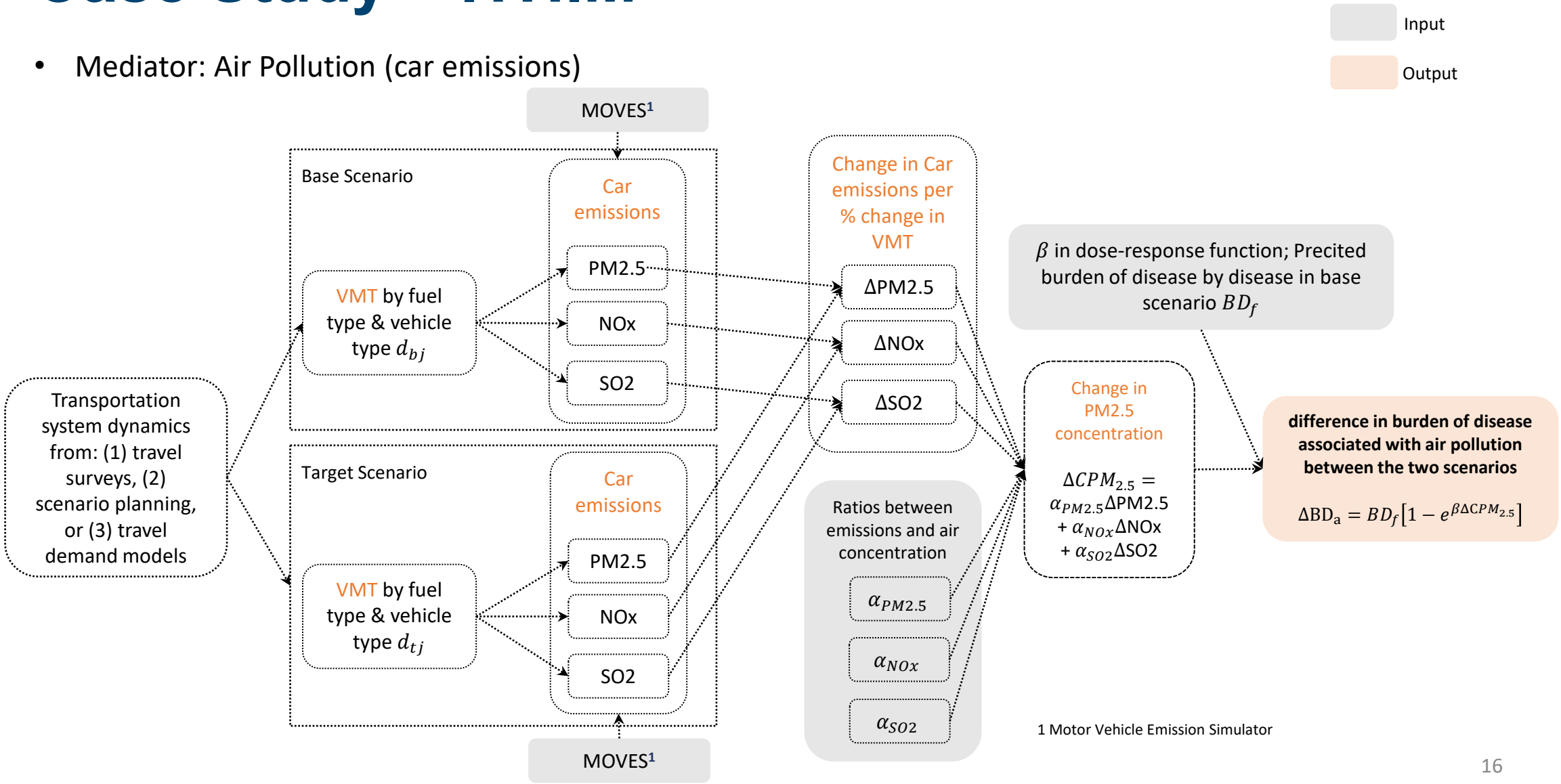
- Mediator: Physical Activity[1]



1 Calculated for each age-sex group separately
2 One MET is the typical energy expenditure of an individual at rest (1 kcal/kg/h).

Case Study – ITHIM

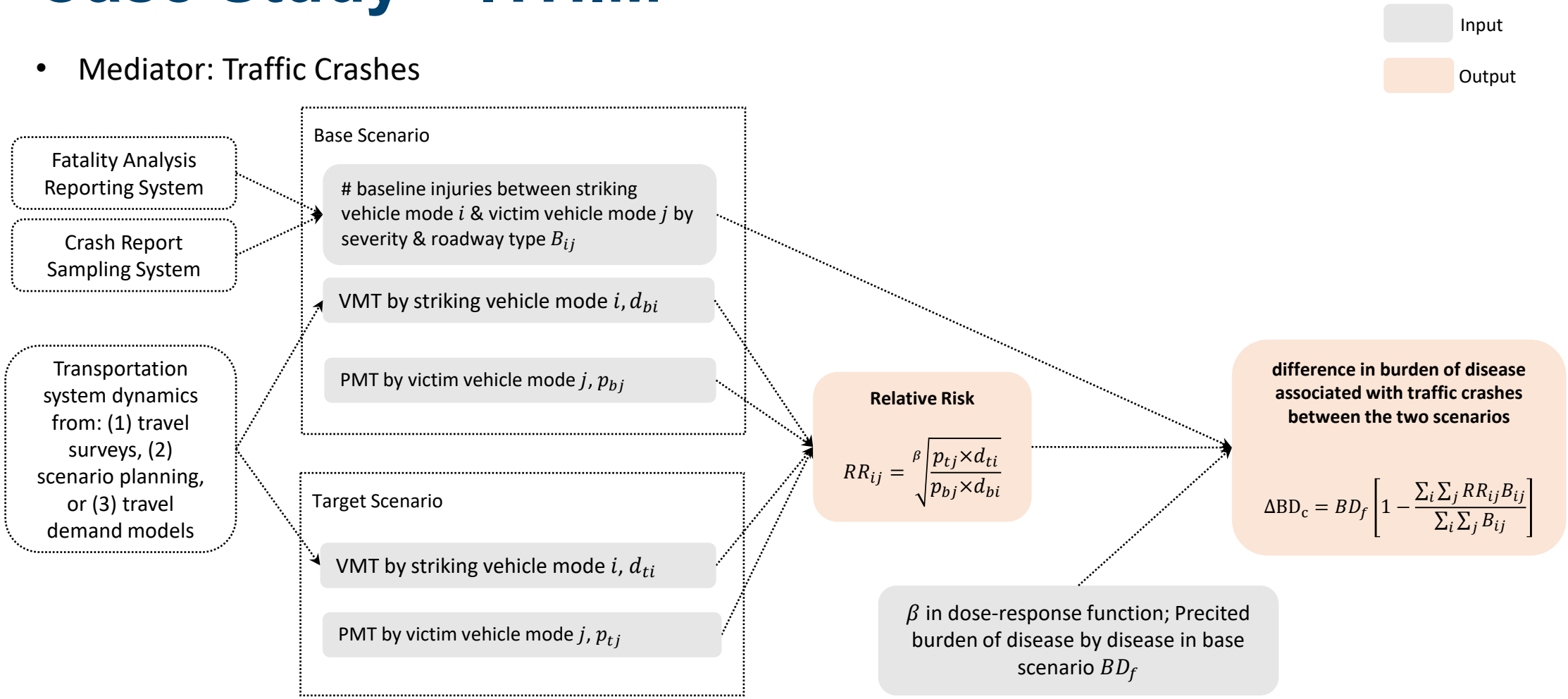
- Mediator: Air Pollution (car emissions)



1 Motor Vehicle Emission Simulator

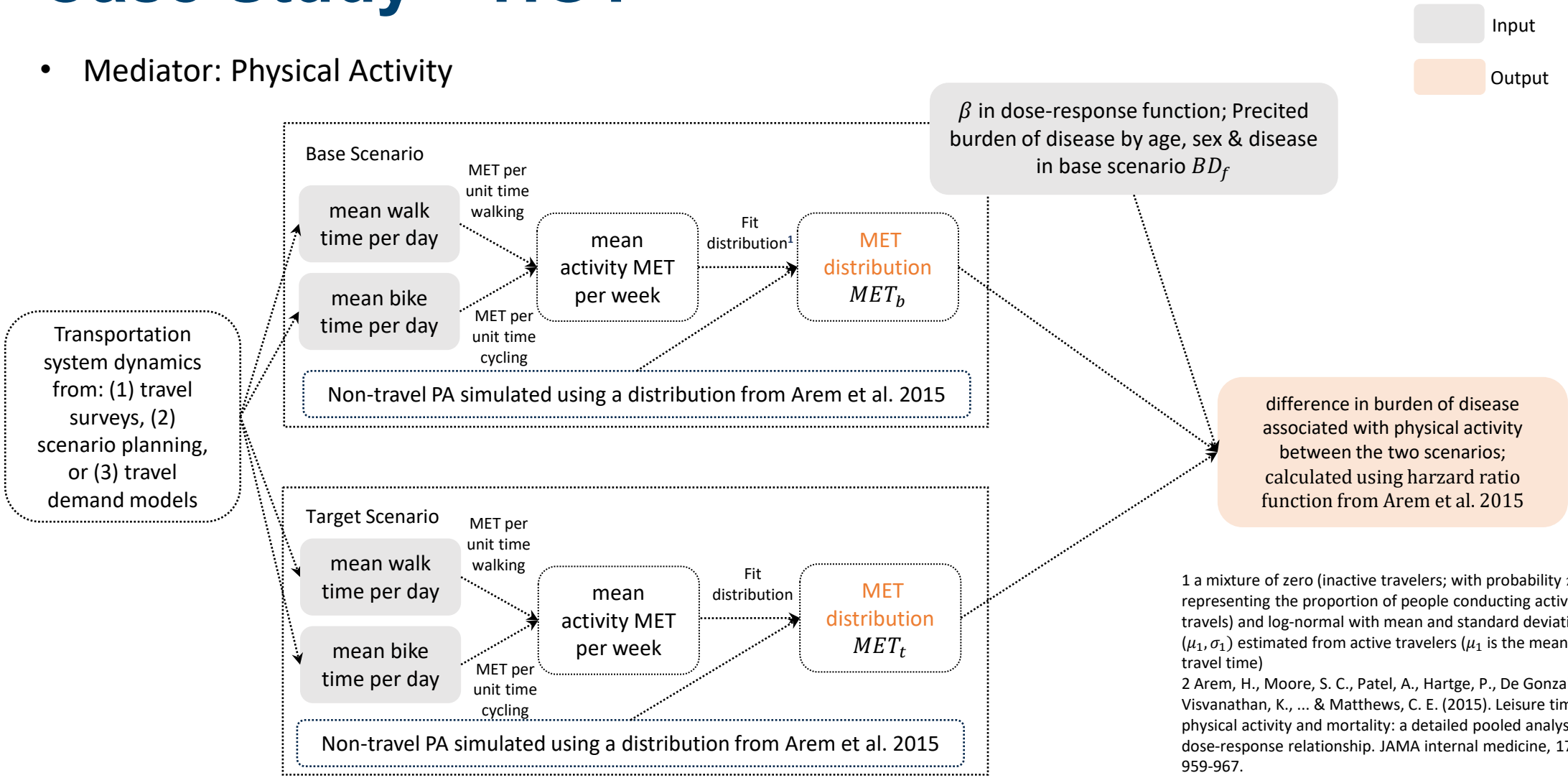
Case Study – ITHIM

- Mediator: Traffic Crashes



Case Study – HOT

- Mediator: Physical Activity

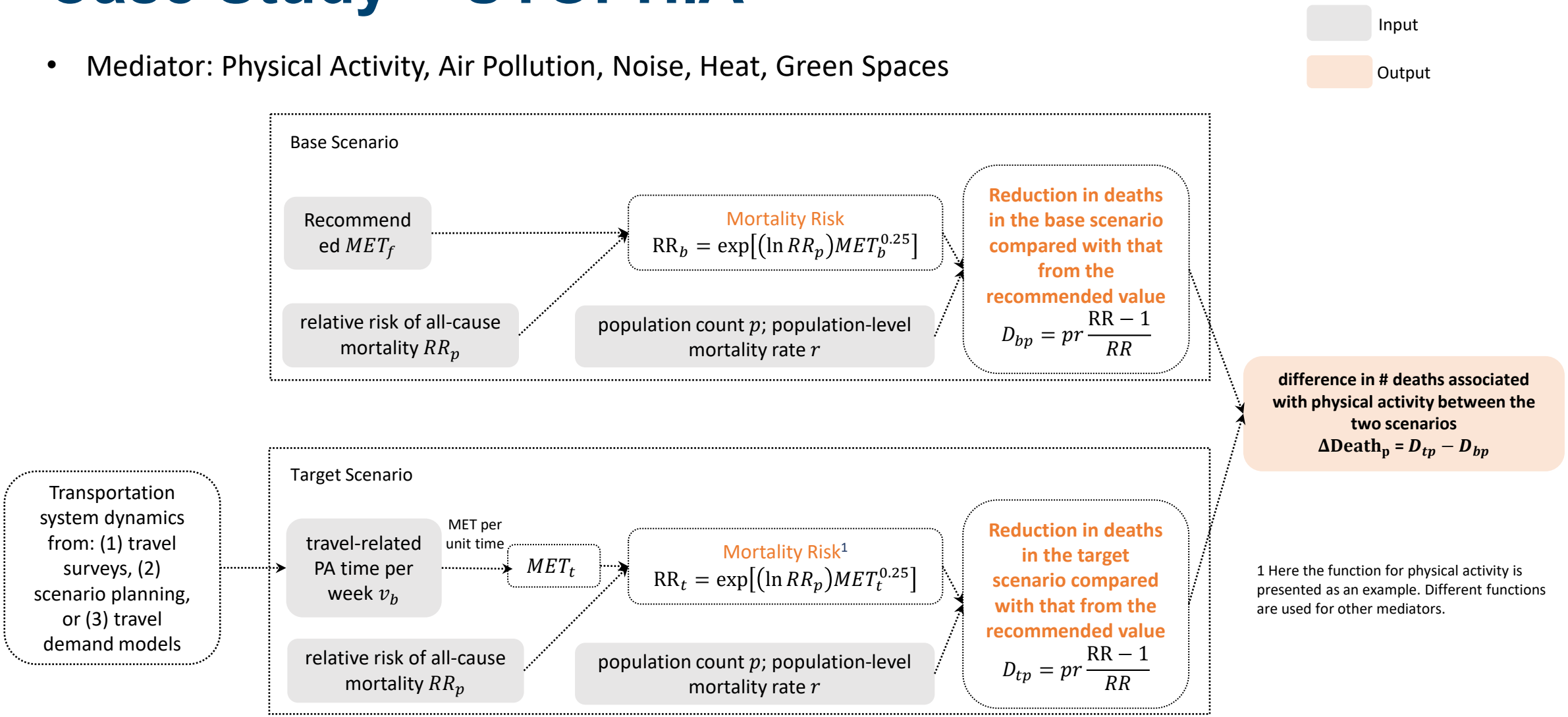


1 a mixture of zero (inactive travelers; with probability π_0 representing the proportion of people conducting active travels) and log-normal with mean and standard deviation (μ_1, σ_1) estimated from active travelers (μ_1 is the mean active travel time)

2 Arem, H., Moore, S. C., Patel, A., Hartge, P., De Gonzalez, A. B., Visvanathan, K., ... & Matthews, C. E. (2015). Leisure time physical activity and mortality: a detailed pooled analysis of the dose-response relationship. JAMA internal medicine, 175(6), 959-967.

Case Study – UTOPHIA

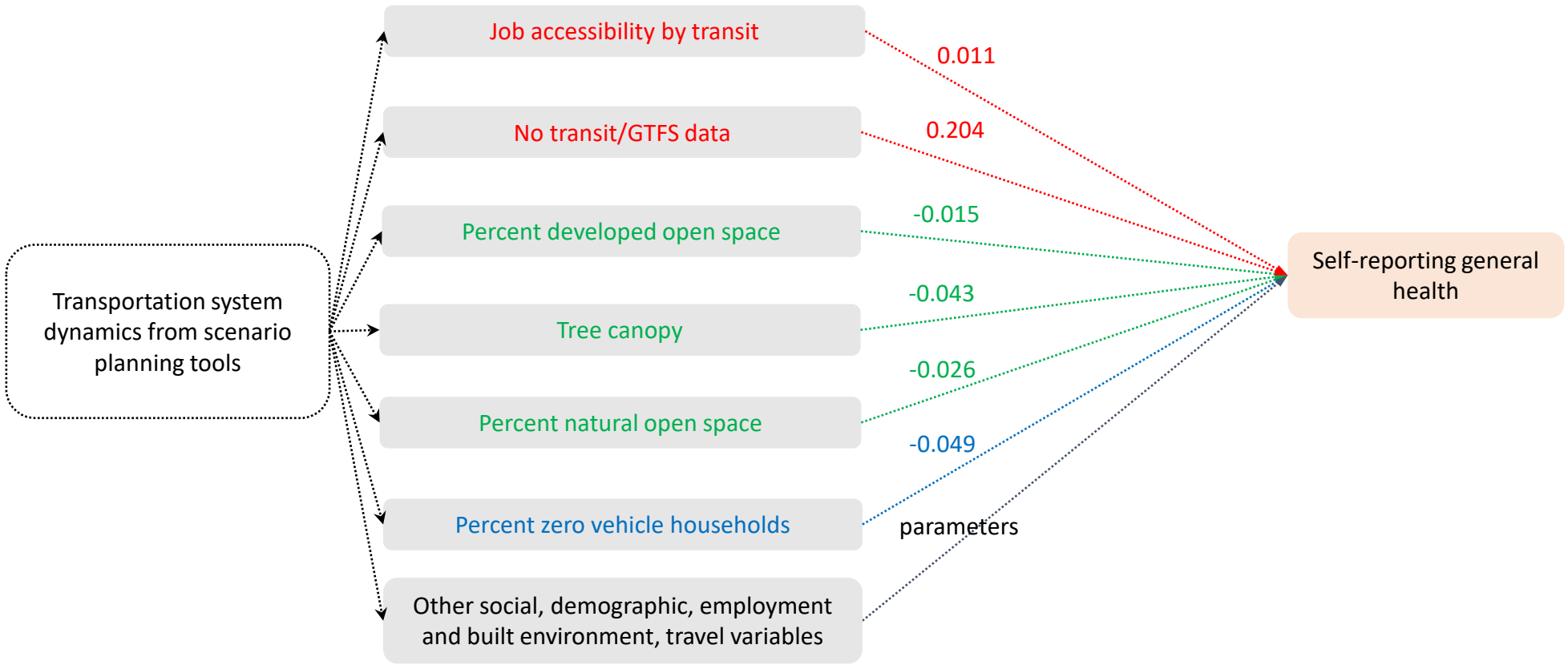
- Mediator: Physical Activity, Air Pollution, Noise, Heat, Green Spaces



1 Here the function for physical activity is presented as an example. Different functions are used for other mediators.

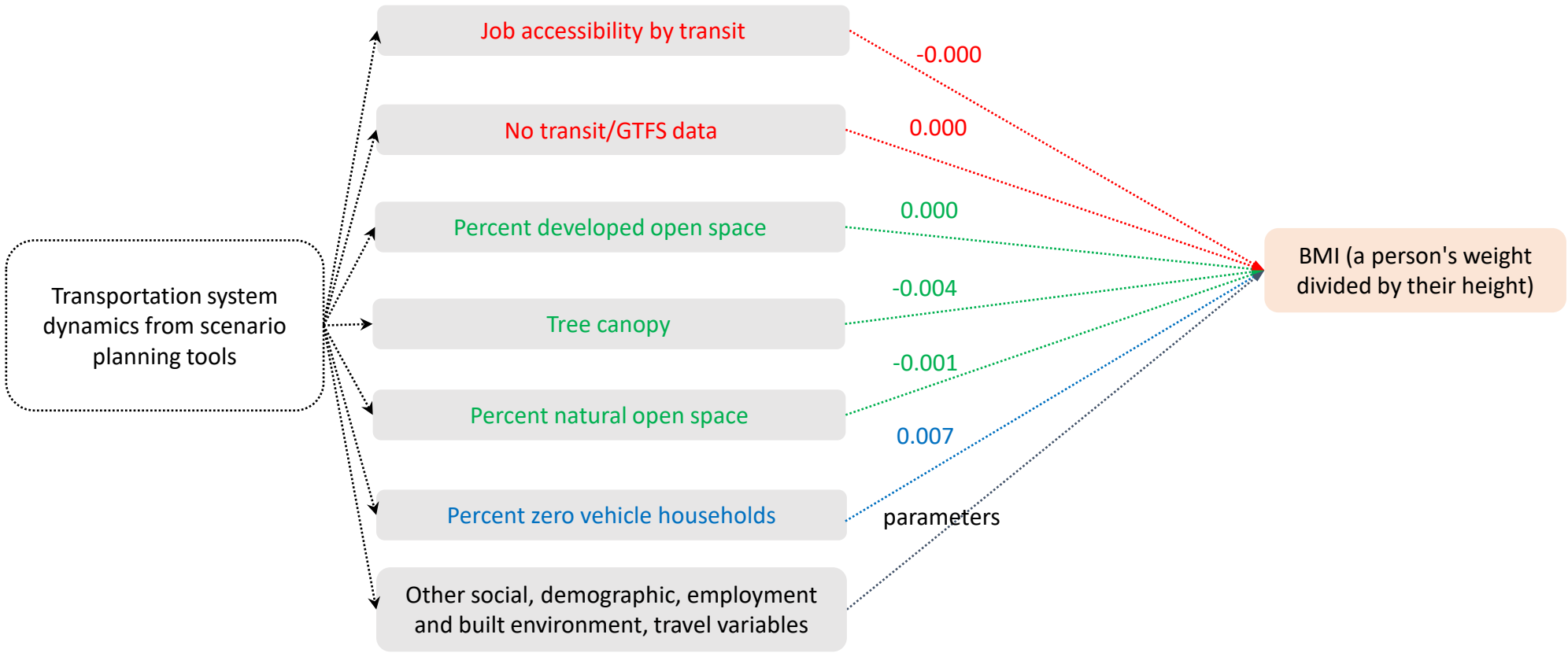
Case Study – N-PHAM

- Mediator: Green & Blue Space (green fonts), Access (red fonts), Mobility Independence (blue fonts)



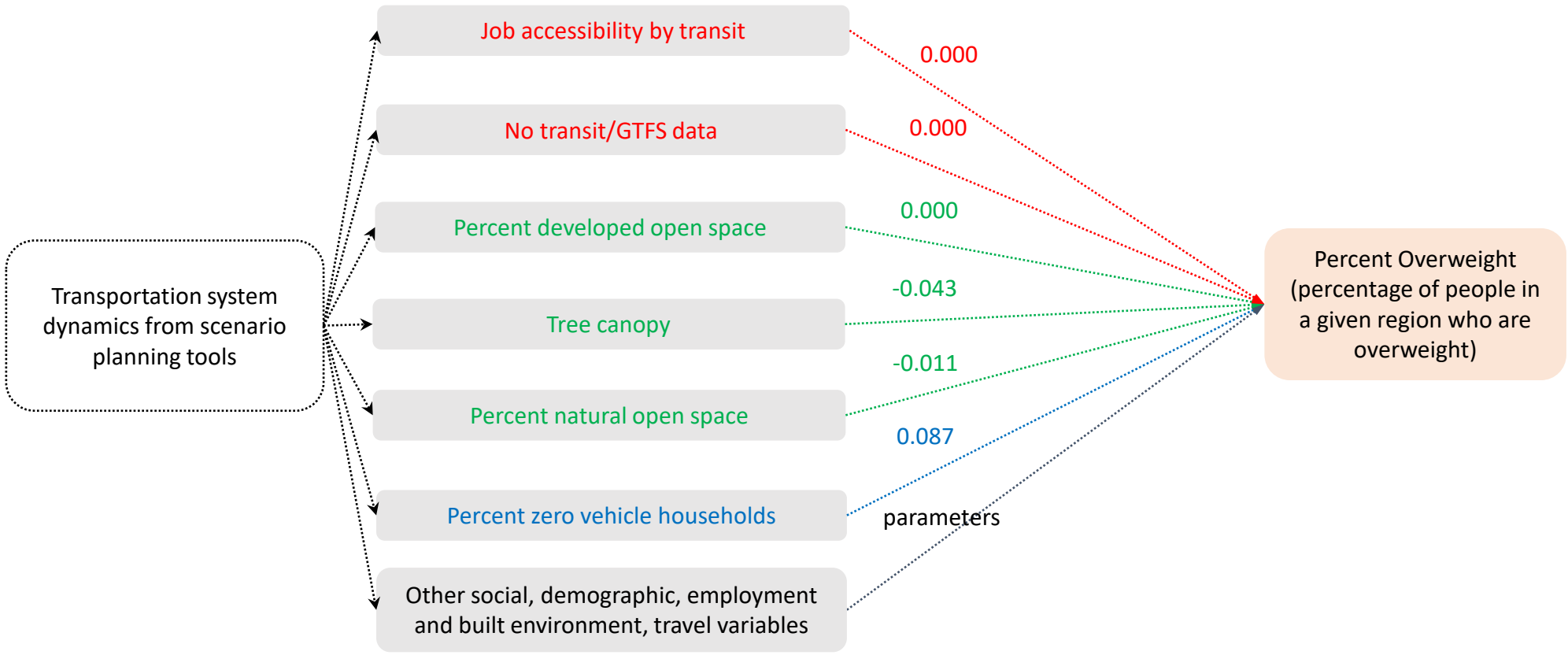
Case Study – N-PHAM

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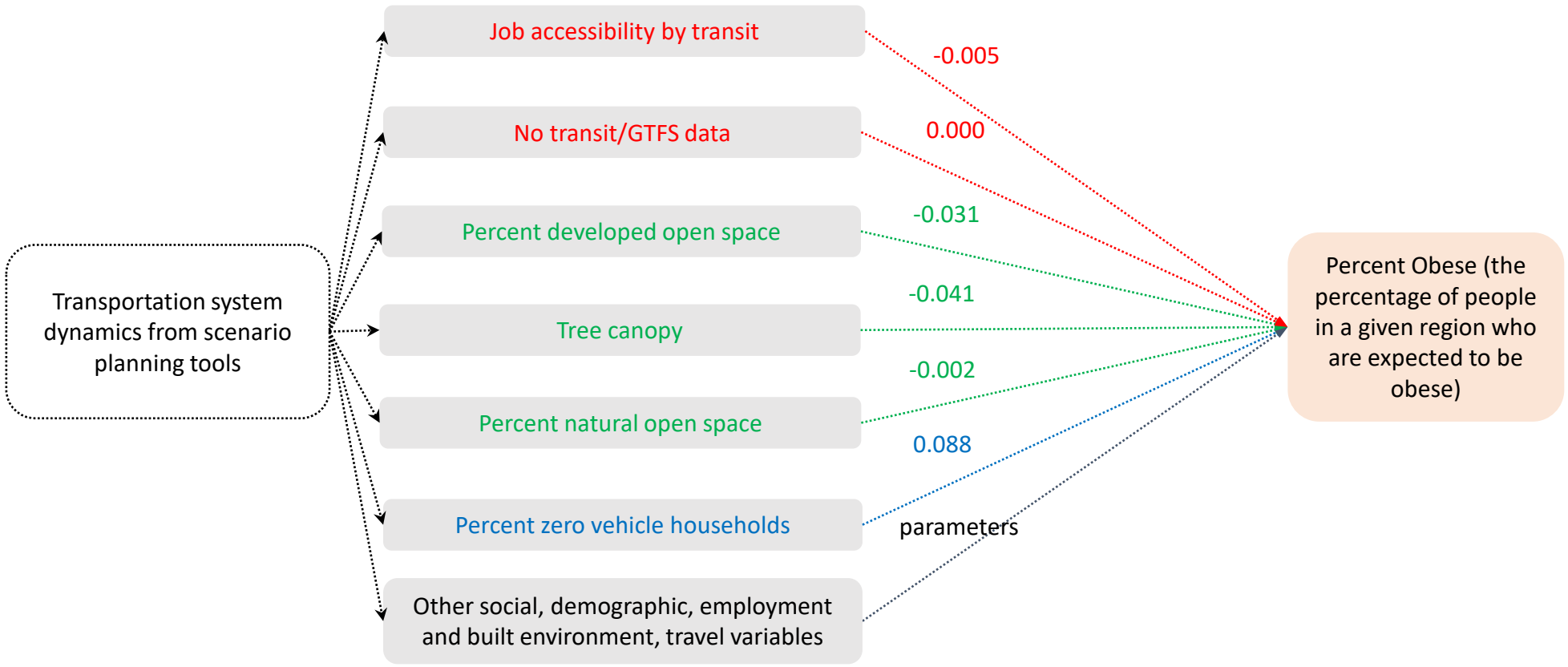
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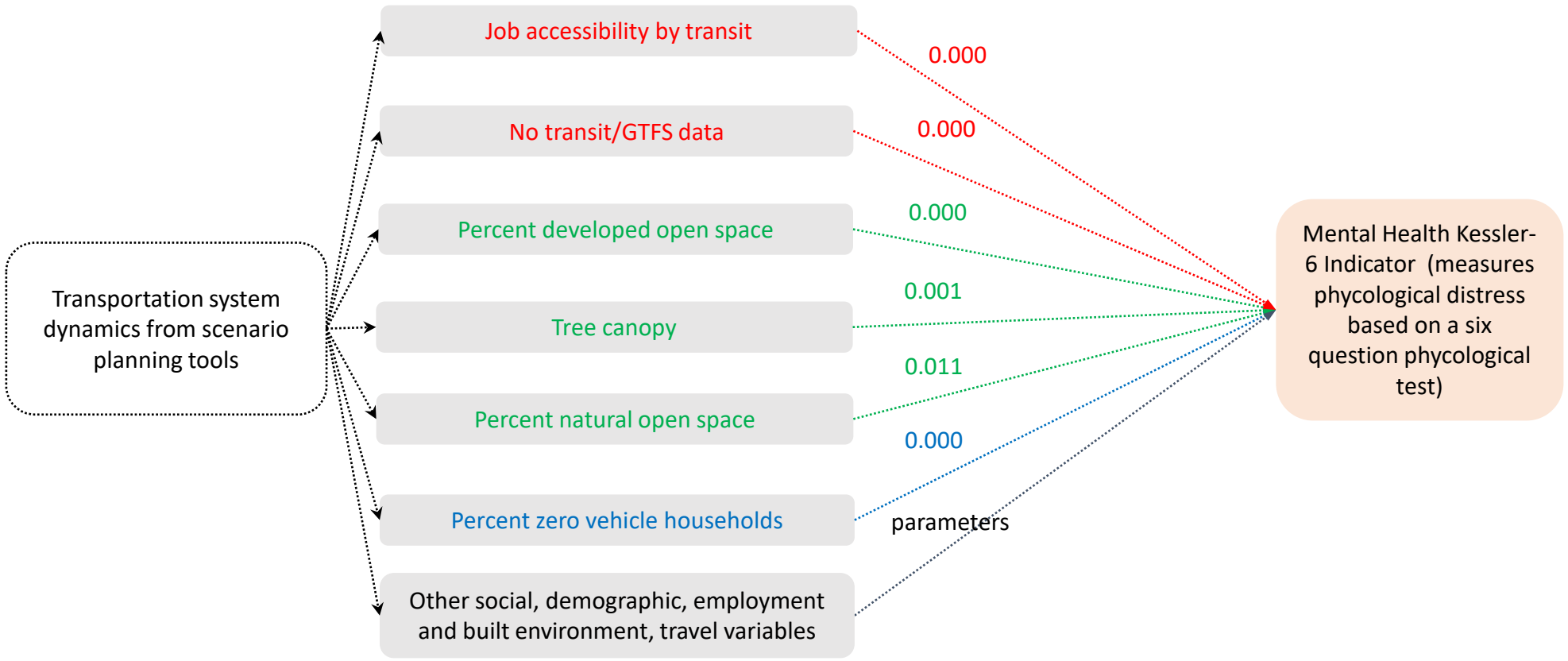
Case Study – N-PHAM

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Case Study – N-PHAM

- Mediator: Green & Blue Space (green fonts), Access (red fonts), Mobility Independence (blue fonts)



Results – Summary

	Creator	Availability	Transport Modes	Mediators Considered	Health Outcomes	Spatial disaggregation[3]
Health Economic Assessment Tool (HEAT)[1]	World Health Organization	Y (webtool or software)	Walking, cycling	Physical Activity, Air Pollution, Traffic Crashes	All-cause mortality	N
Integrated Transport and Health Impact Model (ITHIM)[1]	Cambridge University	Y (webtool, R package)	Walking, cycling, transit, driving	Physical Activity, Air Pollution, Traffic Crashes	Cardiovascular disease, diabetes, dementia, depression, colon & breast cancer, traffic injuries	N
Health-Oriented Transportation (HOT) Model	University of Wisconsin	Y (webtool, R package)	Walking, cycling	Physical Activity	All-cause mortality	N
Urban and TranspOrt Planning Health Impact Assessment (UTOPHIA)	Natalie Mueller et al.	N	Walking, cycling, driving	Physical Activity, Air Pollution, Noise, Heat, Green Spaces	All-cause mortality	Y
National Public Health Assessment Model (N-PHAM)	Urban Design 4 Health	N (webtool)	Walking[2], cycling[2], transit	Green & Blue Space, Access, Mobility Independence	Overall health, mental health, BMI, overweight, obese	Y

Recommended Models

[1] HEAT & ITHIM also model carbon emissions but only focus on their economic impacts, not health-related outcomes.

[2] N-PAHM models the impacts of social, economic, and built-environment factors on active transportation usage & health select health outcomes. But a direct link between active transportation and health outcomes is not considered.

[3] Whether the analysis can be conducted for a geographic unit (e.g., census block) within an area of interest.

Next Step

Pathways

Identify Health Impact of Transportation Activity through multiple pathways

1

Model

Explore Transport and Health Impact Models (e.g., ITHIM, HEAT)

2

Quantification

Health Impact Quantification Method

3

Roadmap

Develop a Roadmap to Health Impact Assessment for Transportation Systems

4

Discussion

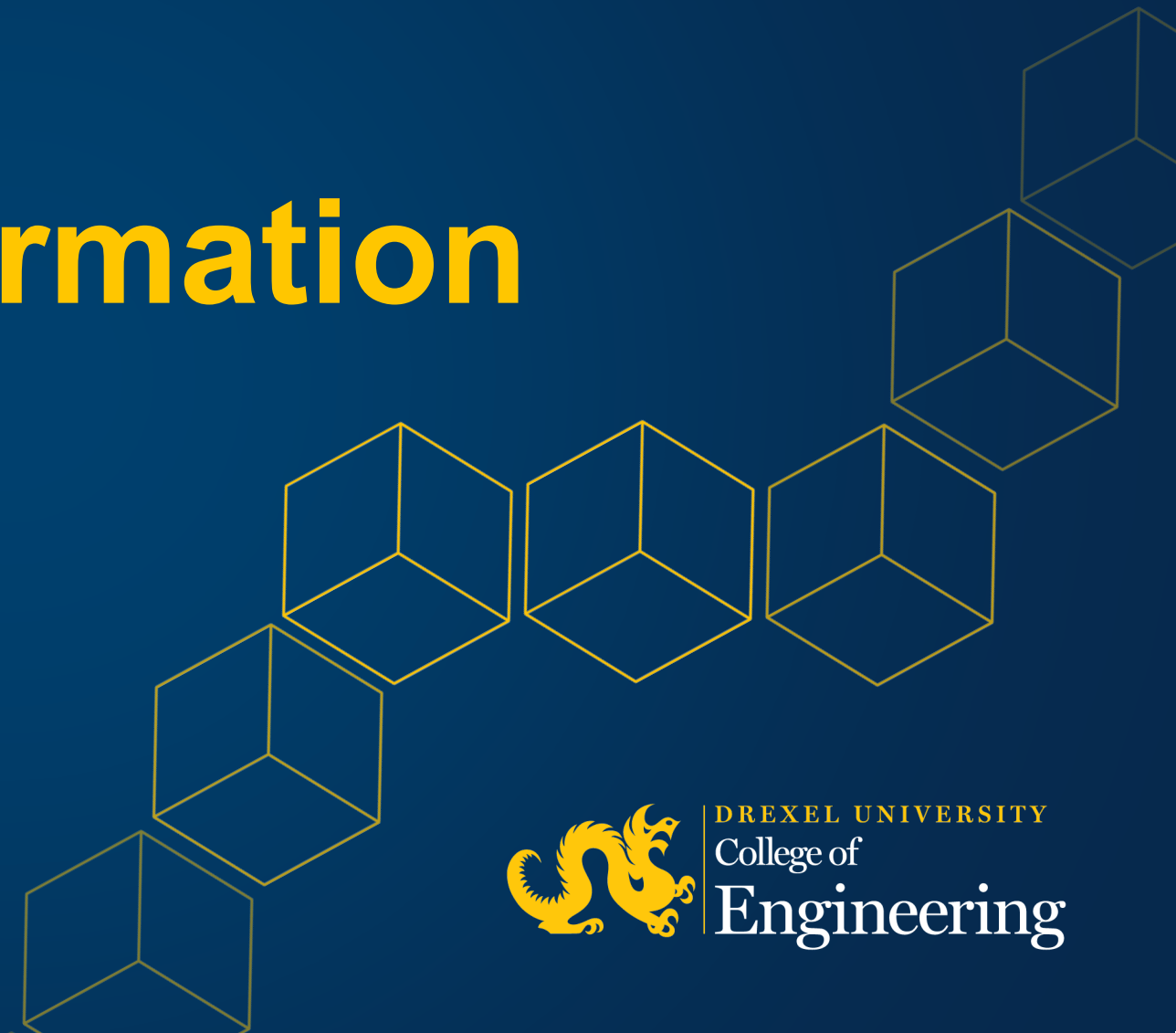
- What are DVRPC's needs in terms of health impact modeling?
  - What does DVRPC want to use it for?
  - What mediators and pathways to consider?
  - What data are available?
  - ….
- What funding sources are available?
  - DOT, NSF, NIH…?

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