Potential Health Implications of New Mobility

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Part I

Transportation and Health: The 14 Pathways and Technology Implications

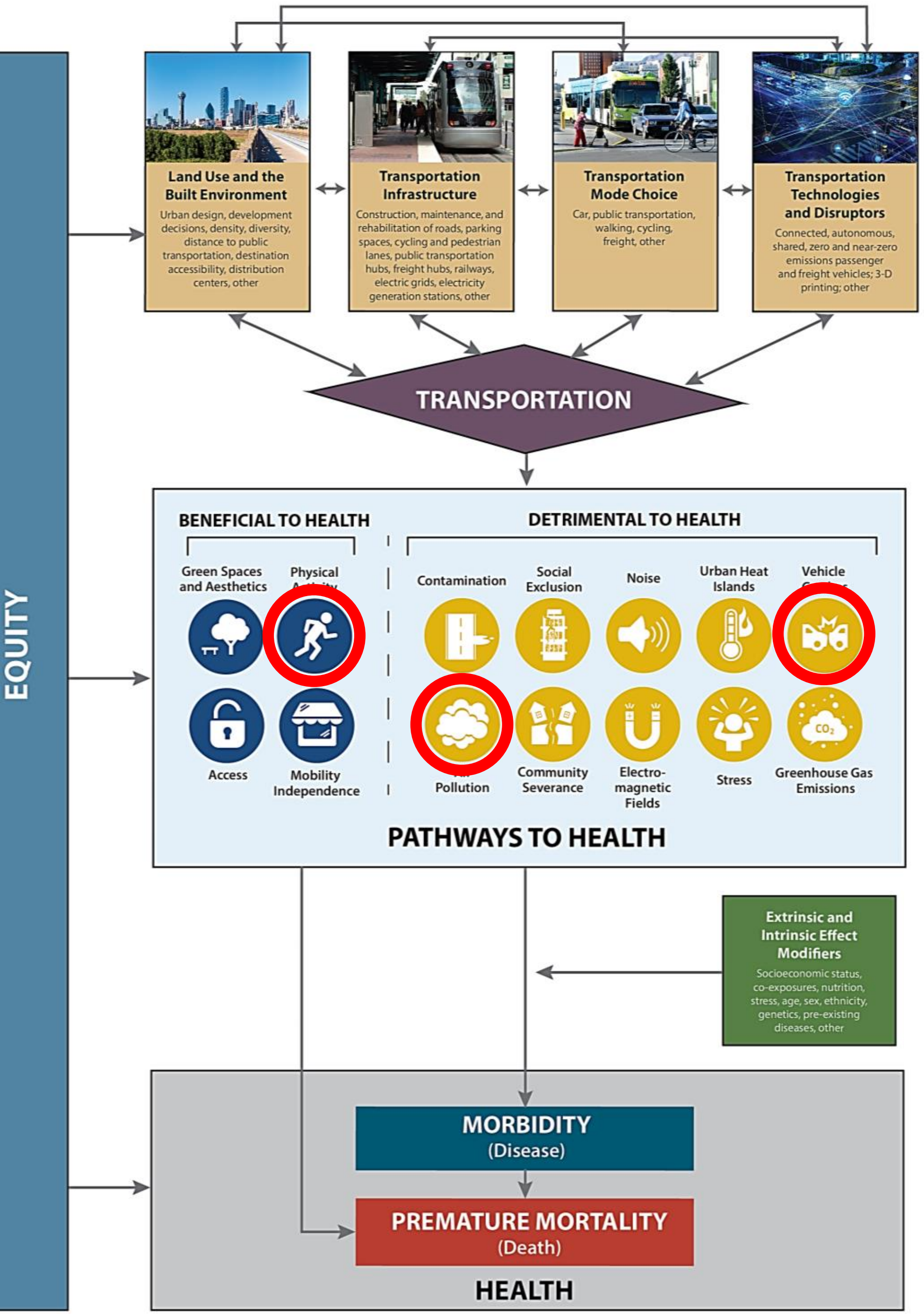
Part II

Case Studies on Impacts of Pathways

Part I: Transportation and Health

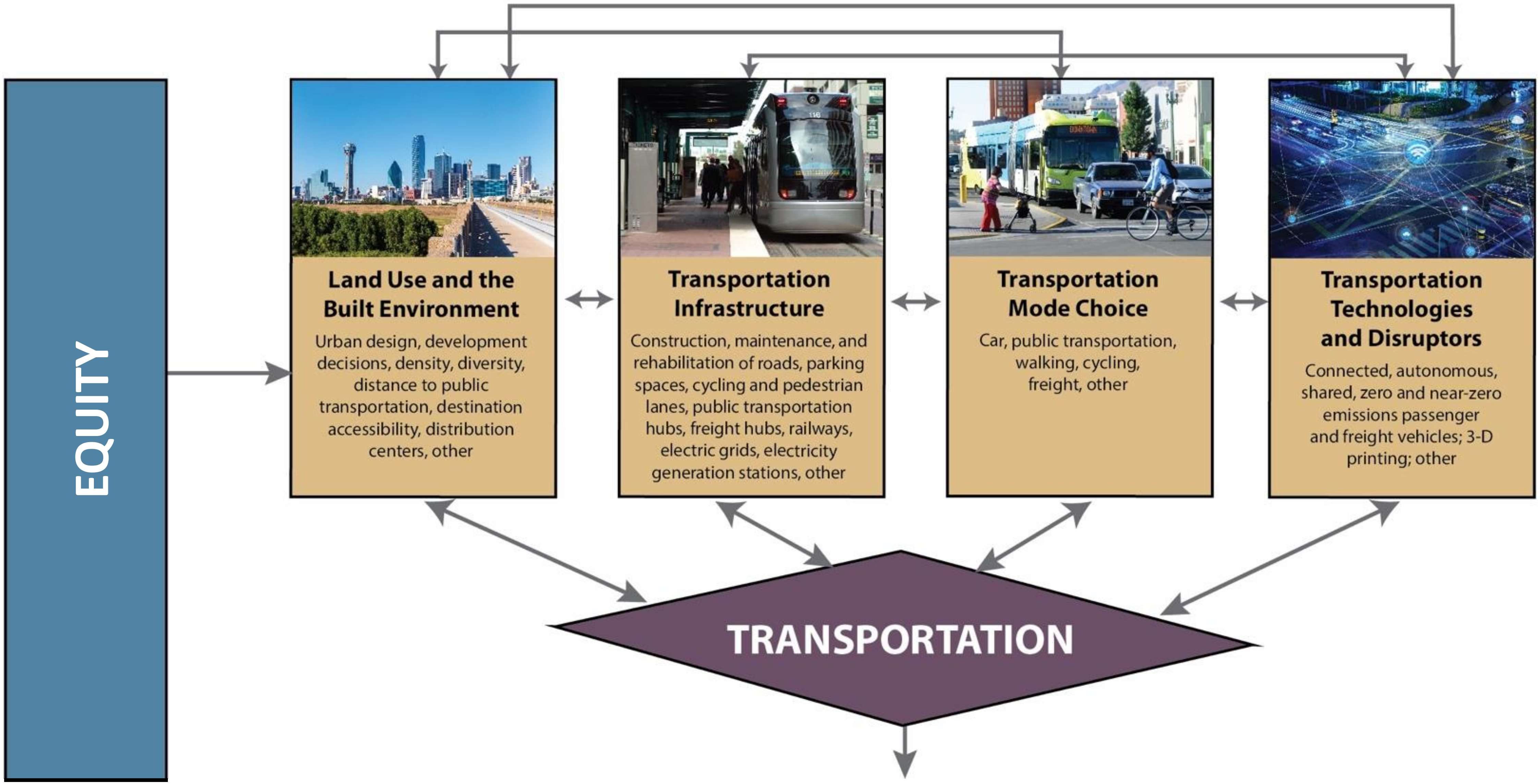
"Recognized Linkages"

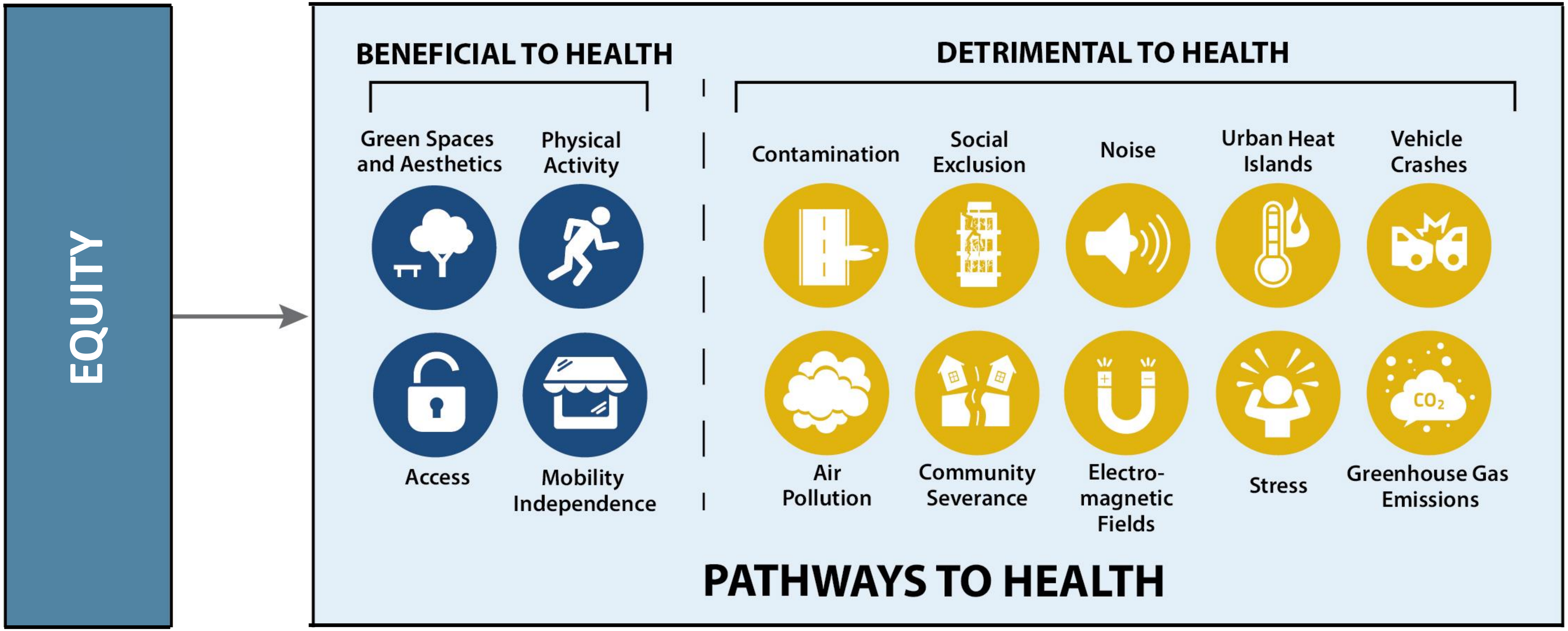
- Each year > 1.5 million deaths and 79 million injuries warranting medical care
  - Low an middle-income countries account for >90% of road fatalities despite having 48% of world's registered vehicles
- Ambient air pollution and physical inactivity – 4.2 and 3.2 million annual global deaths

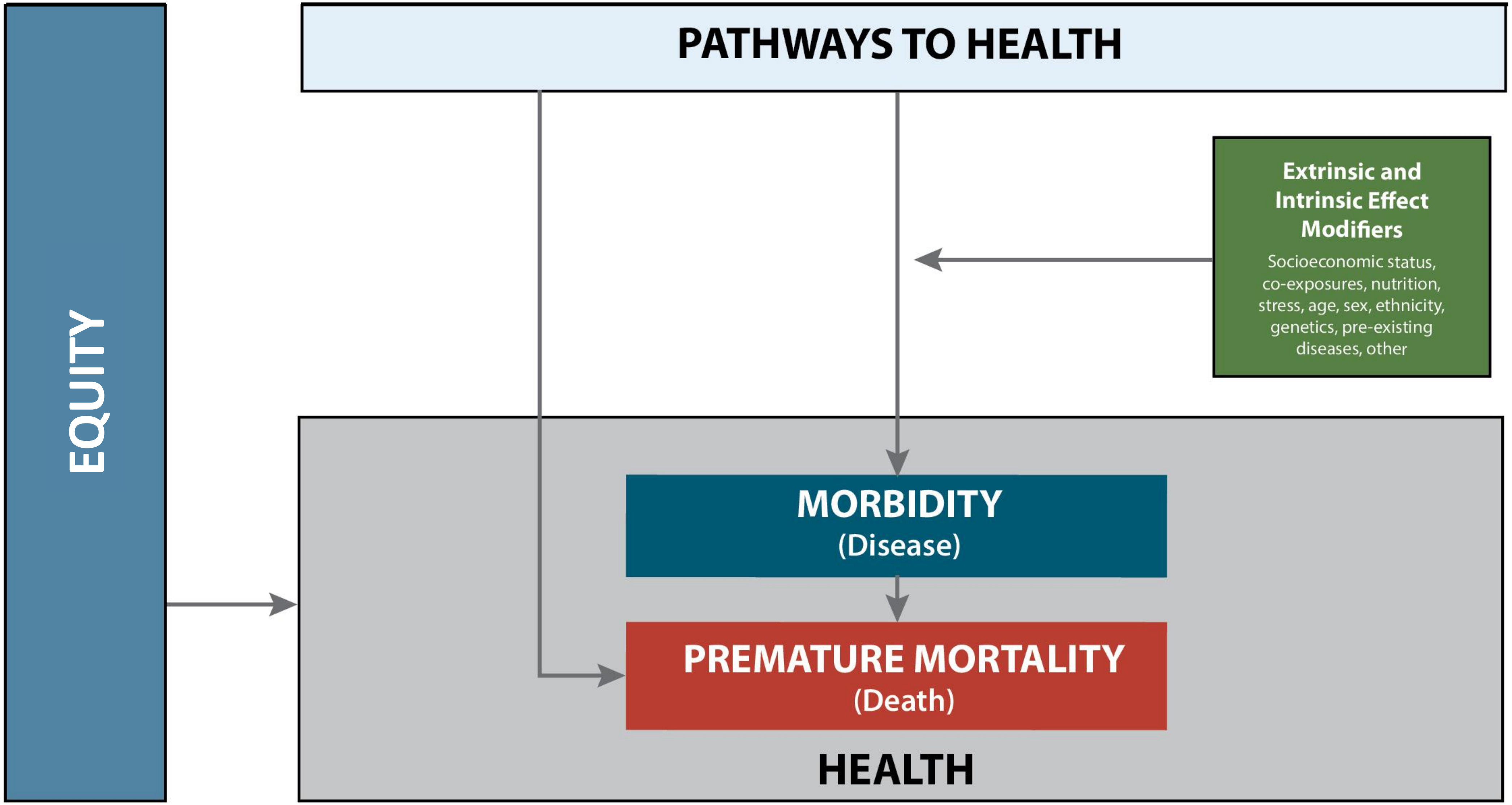


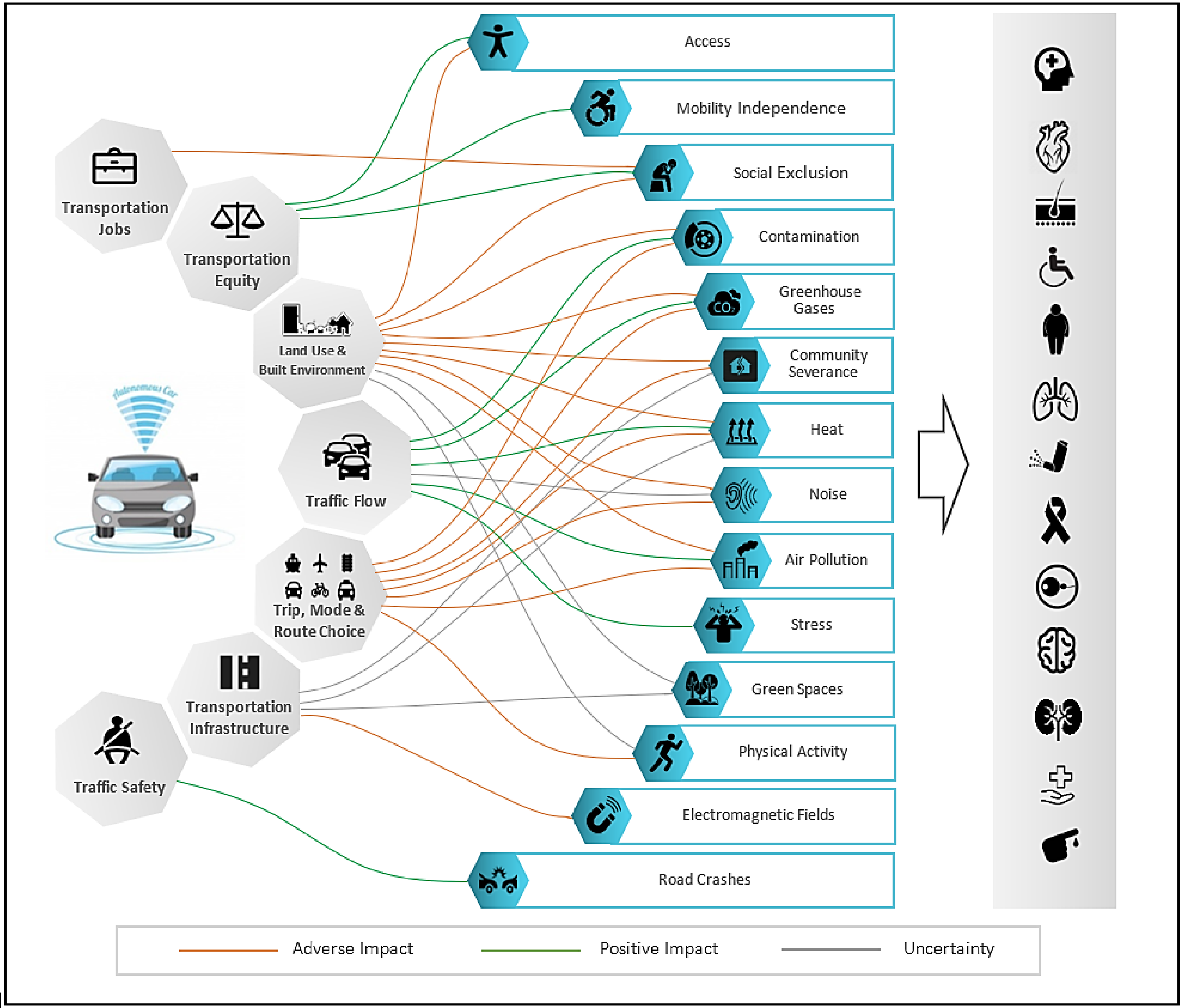
“Less Recognized Linkages”

Khreis, Haneen; Glazener, Andrew; Ramani, Tara; Zietsman, Josias; Nieuwenhuijsen, Mark J.; Mindell, Jennifer S.; Winfree, Gregory D.; and Burke, Thomas A. (2019). Transportation and Health: A Conceptual Model and Literature Review. College Station, Texas: Center for Advancing Research in Transportation Emissions, Energy, and Health, May 2019.


EQUITY
Land Use and the Built Environment
Urban design, development decisions, density, diversity, distance to public transportation, destination accessibility, distribution centers, other
Transportation Infrastructure
Construction, maintenance, and rehabilitation of roads, parking spaces, cycling and pedestrian lanes, public transportation hubs, freight hubs, railways, electric grids, electricity generation stations, other
Transportation Mode Choice
Car, public transportation, walking, cycling, freight, other
Transportation Technologies and Disruptors
Connected, autonomous, shared, zero and near-zero emissions passenger and freight vehicles; 3-D printing; other
TRANSPORTATION


EQUITY
BENEFICIAL TO HEALTH
Green Spaces and Aesthetics
Physical Activity
Access
Mobility Independence
DETRIMENTAL TO HEALTH
Contamination
Social Exclusion
Noise
Urban Heat Islands
Vehicle Crashes
Air Pollution
Community Severance
Electro-magnetic Fields
Stress
Greenhouse Gas Emissions
CO2
PATHWAYS TO HEALTH


PATHWAYS TO HEALTH
EQUITY
Extrinsic and Intrinsic Effect Modifiers
Socioeconomic status, co-exposures, nutrition, stress, age, sex, ethnicity, genetics, pre-existing diseases, other
MORBIDITY (Disease)
PREMATURE MORTALITY (Death)
HEALTH



Sohrabi, Soheil; Khreis, Haneen; Lord, Dominique (2019). "Impacts of Autonomous Vehicles on Public Health: A Review of Literature and Conceptual Model". Under review.

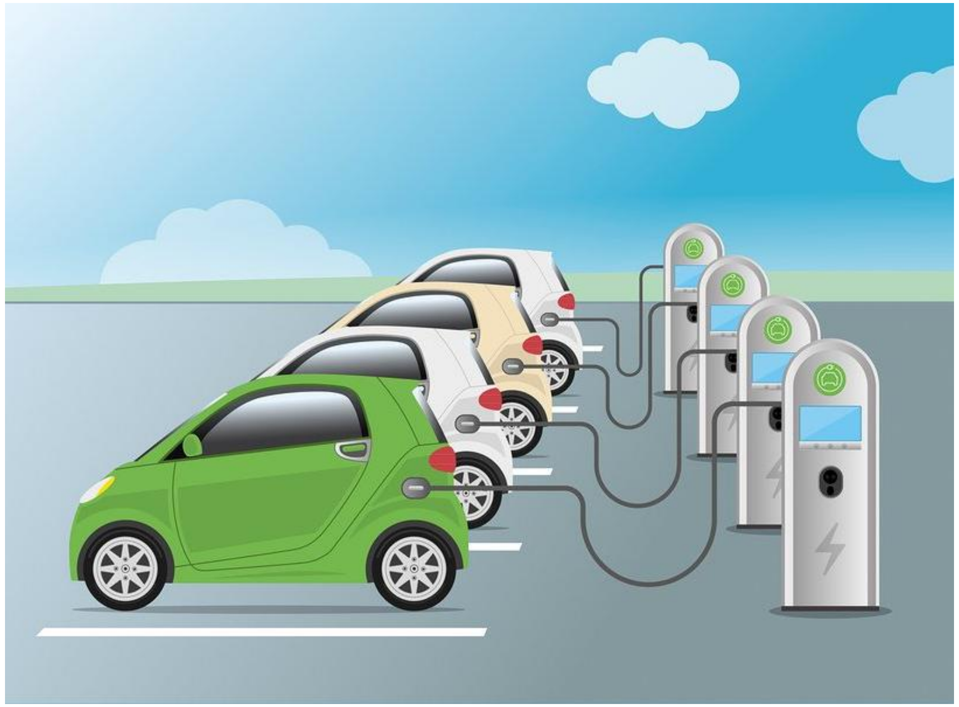
AVs' implementation is linked to public health through 32 linkages. AVs may adversely impact health through 16

Transportation point of impact	Link number	Health pathway	Potential direction of impact
Transportation jobs	1	Social exclusion	Adverse
Transportation equity	2	Access	Positive
	3	Mobility independence	Positive
	4	Social exclusion	Positive
Land use and built environment	5	Access	Uncertain
	6	Social exclusion	Adverse
	7	Contamination	Adverse
	8	Greenhouse gases	Adverse
	9	Community severance	Adverse
	10	Heat	Adverse
	11	Noise	Adverse
	12	Air pollution	Adverse
	13	Green spaces	Uncertain
	14	Physical activity	Uncertain
Traffic flow	15	Contamination	Positive
	16	Greenhouse gases	Positive
	17	Heat	Positive
	18	Noise	Uncertain
	19	Air pollution	Positive
	20	Stress	Positive
Trip, mode and route choice	21	Contamination	Adverse
	22	Greenhouse gases	Adverse
	23	Community severance	Adverse
	24	Heat	Adverse
	25	Noise	Adverse
	26	Air pollution	Adverse
	27	Physical activity	Adverse
Transportation infrastructure	28	Community severance	Uncertain
	29	Heat	Uncertain
	30	Green spaces	Uncertain
	31	Electromagnetic fields	Adverse
Traffic safety	32	Road crashes	Positive

AV- Autonomous Vehicle

For beneficial implementation of AVs, supporting policies are required to govern:

- ✓ Urban sprawl (TDM, urban boundaries)
- ✓ CAVs ownership (shared ownership)
- ✓ Ridesharing and public transit
- ✓ Job loss (smoother transition)
- ✓ AVs infrastructure and limiting EMF
- ✓ Electrification of AVs (given electricity is clean)
- ✓ Monitor and limit non-tailpipe emissions



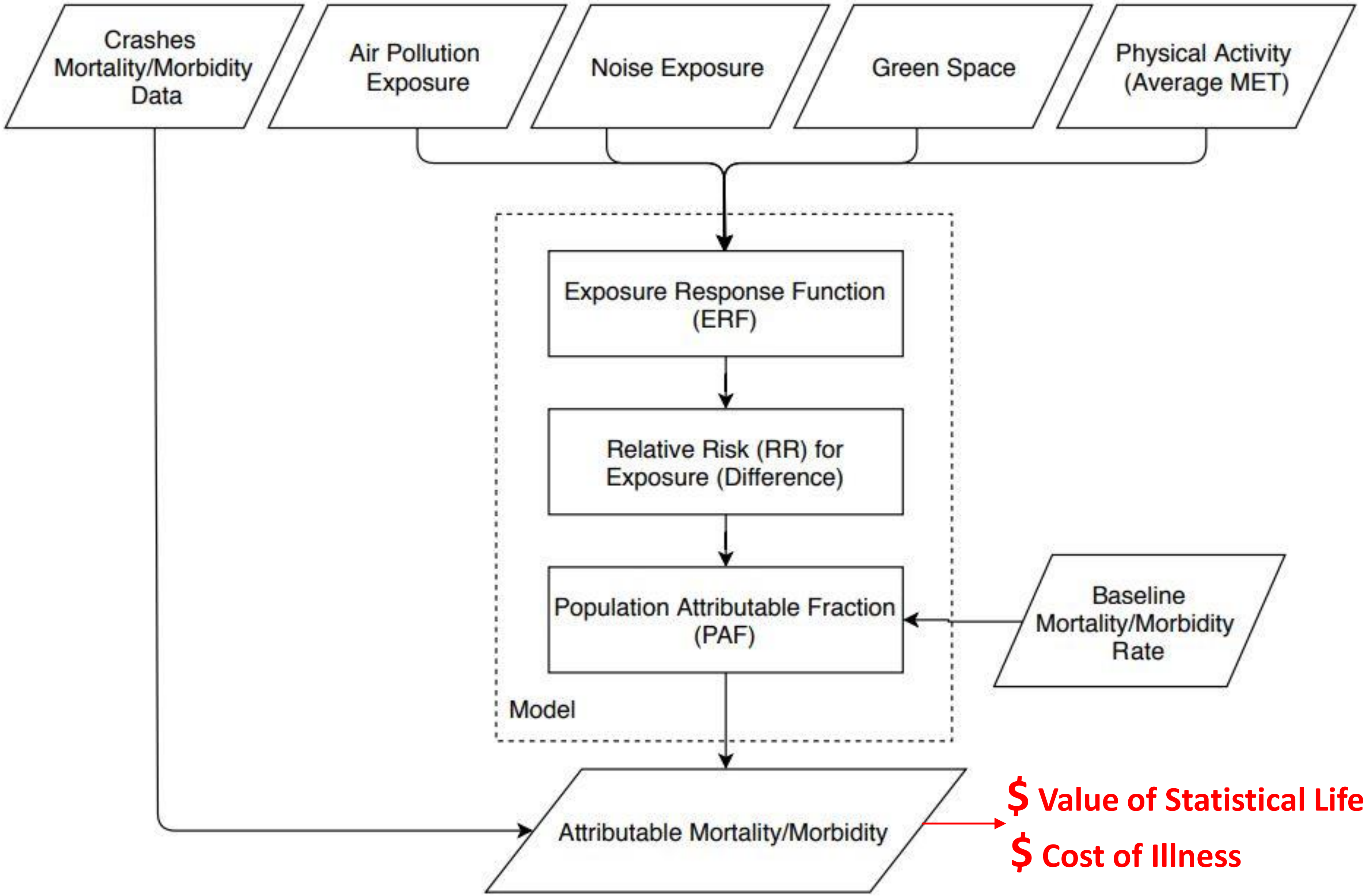
Research Needs:

Quantifying and monitoring the burden of disease of AVs implementation (19 papers)

AVs = autonomous vehicles
TDM = transportation demand management
EMF = electromagnetic field

Part II: Case Studies on Impacts of Pathways

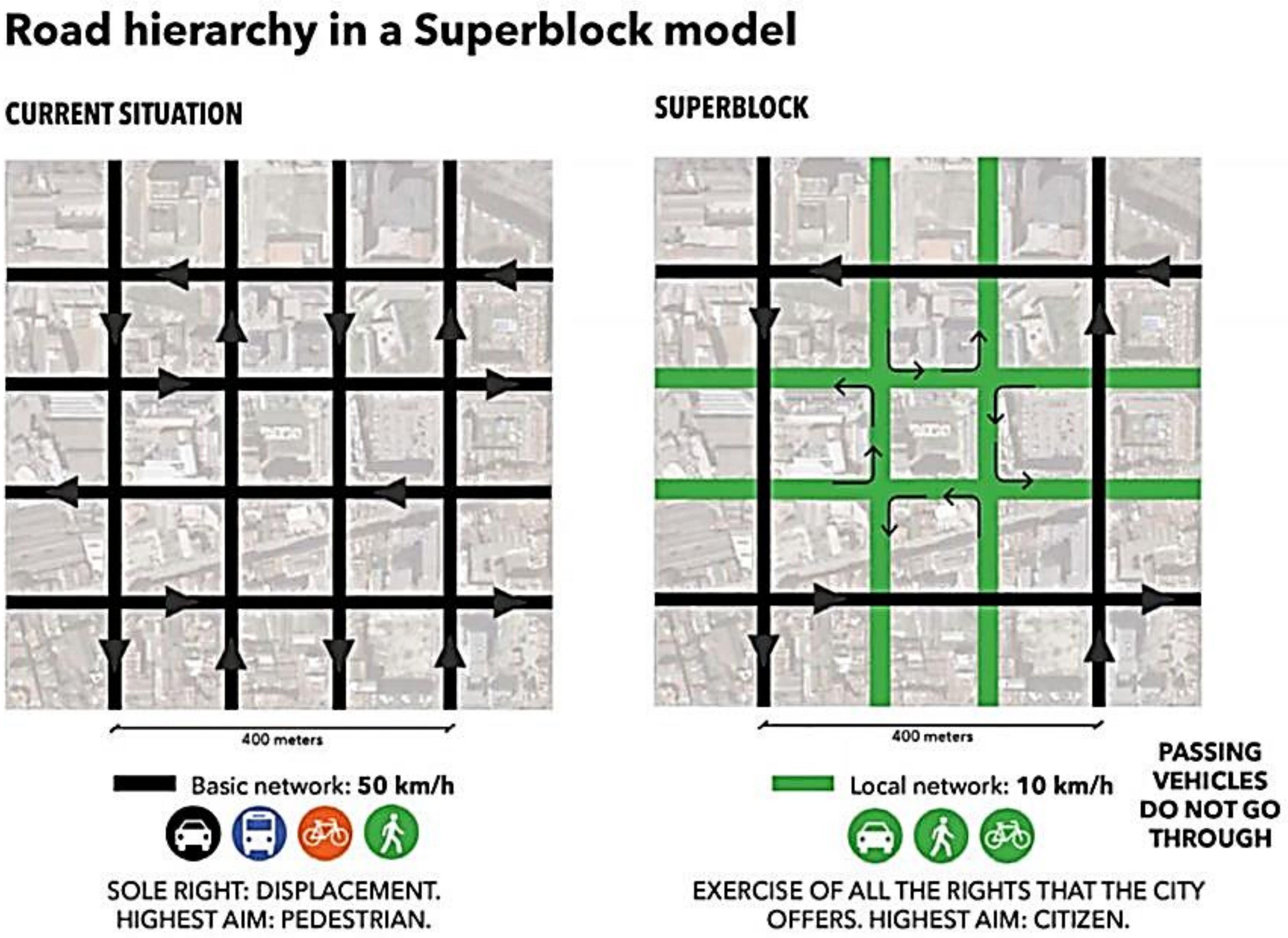
Quantitative Health Impact Assessment



Case Study 1→ Changing the Urban Design of Cities for Health: The Barcelona Superblock Model

Rationale

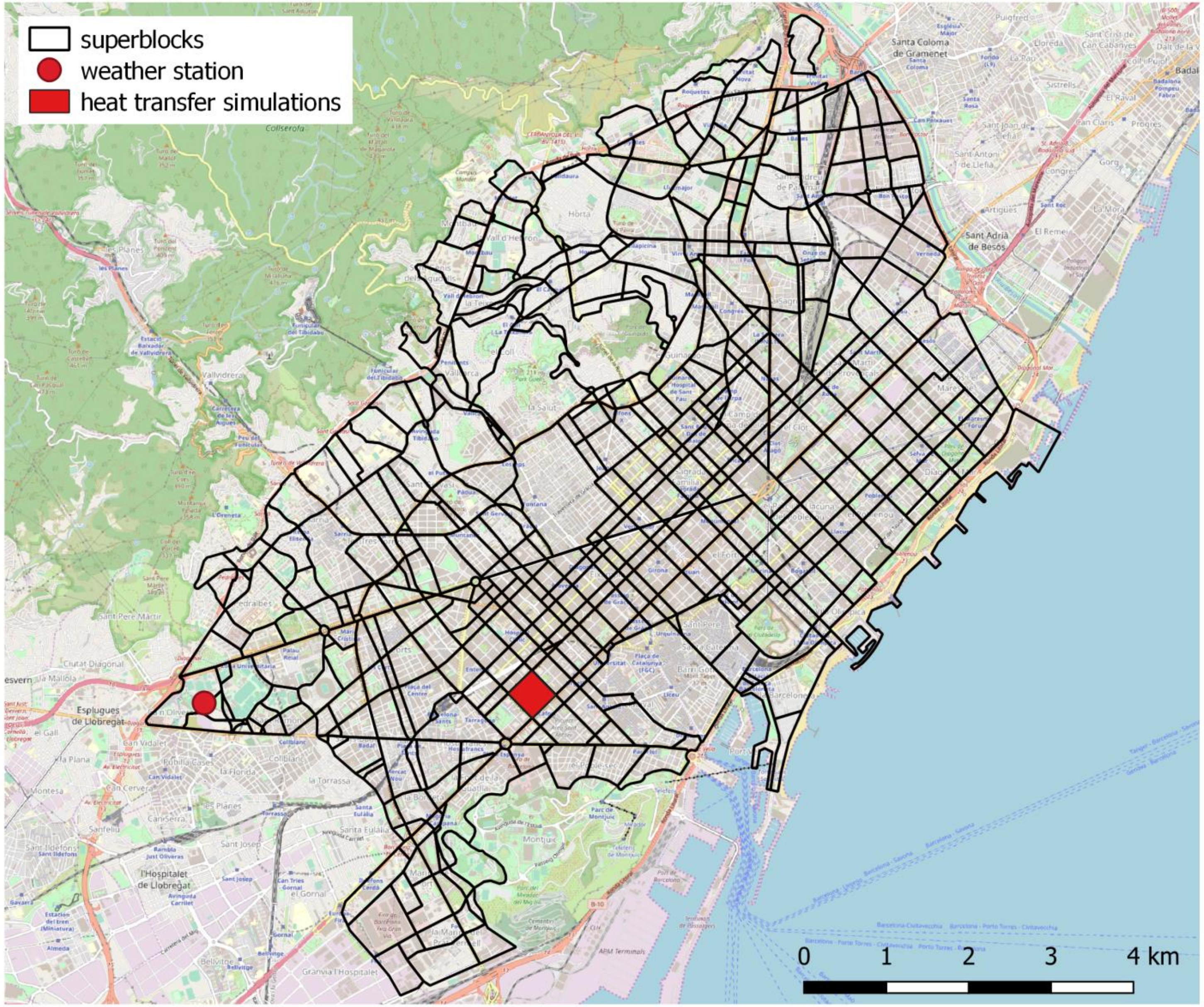
- Barcelona has 1.6 million people on only 100 km^2
- Highest traffic density in Europe $\rightarrow$ 6,000 vehicles circulating/km^2
- High air and noise pollution levels
- Little green/open space $\rightarrow$ amplifying anthropogenic heat (city center 8^{oC} > than surrounding areas)
- 503 super-blocks are proposed $\rightarrow$ a land-use intervention to reclaim space for people



- Segregated bus, cycling and pedestrian lanes on basic network
- Bus stops at each superblock intersection
- Buses at high frequency
- Development of public open and green space

Aim and Study Setting

- Estimate preventable premature mortality attributable to Superblocks:
    - Physical activity (PA)
    - Air pollution (NO_2)
    - Noise
    - Access to green space
    - Mitigation of urban heat island
- Barcelona residents ≥ 20 years (N=1,301,827) on the projected superblock census area level (N=503)



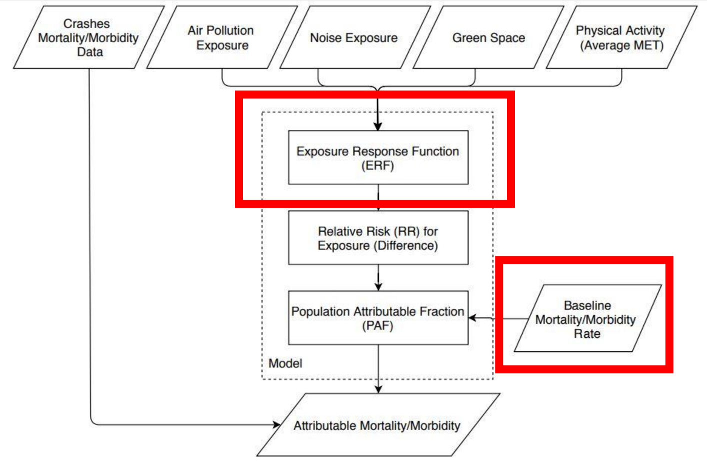


Table. Risk estimates for mortality by exposure domain

Exposure	Risk estimate	Exposure	Health effect	Study design	Reference
Physical activity	RR = 0.81 (95% CI: 0.76, 0.85)	11 versus 0 MET h/ week	All-cause mortality	Meta-analysis	Woodcock et al. 2011
NO_2	RR = 1.02 (PI: 0.99, 1.06)	per 10 μg/ m^3	All-cause mortality	Meta-analysis	Atkinson et al. 2018
Noise	HR = 1.038 (95% CI: 1.019, 1.0.58)	per 10 dB L_{den}(Road)	CVD mortality	Cohort study	Héritier et al. 2017
Green space	RR = 0.99 (95% CI: 0.98, 1.01)	per 10% increase in greenness	All-cause mortality	Meta-analysis	Gascon et al. 2015
Heat	RR= 1.19 (95% CI: 1.16-1.23)	99th versus 74th temperature percentile	All-cause mortality	Time-series study	Guo et al. 2014

CVD=cardiovascular disease; HR=hazard rate; L_{den}=EU day-evening-night noise indicator with 5 dB and 10 dB weights for the evening and night time, respectively; MET=metabolic equivalent of task (1 MET = 1 kcal/ kg/ h); PI=prediction interval; RR=relative risk; 95% CI=95% confidence interval

The natural-cause mortality rate was 1,144 deaths/ 100,000 persons in Barcelona in 2015

Methods – Exposure-Response Functions

Methods – Exposure Changes

Results under review – contact Haneen for more information

Mueller, Natalie; Rojas-Rueda, David; Khreis, Haneen; Cirach, Marta; Ballester, Joan; Bartoll, Xavier; Daher, Carolyn; Deluca, Anna; Echave, Cynthia; Milà, Carles; Marquéz, Sandra; Palou, Joan; Pérez, Catherine; Tonne, Cathryn; Rueda, Salvador; Nieuwenhuijsen, Mark on behalf of the Superblock evaluation team (2019). “Changing the Urban Design of Cities for Health: The Barcelona Superblock Model. Under review.

Results - Attributable Premature Mortality

Results under review – contact Haneen for more information

Mueller, Natalie; Rojas-Rueda, David; Khreis, Haneen; Cirach, Marta; Ballester, Joan; Bartoll, Xavier; Daher, Carolyn; Deluca, Anna; Echave, Cynthia; Milà, Carles; Marquéz, Sandra; Palou, Joan; Pérez, Catherine; Tonne, Cathryn; Rueda, Salvador; Nieuwenhuijsen, Mark on behalf of the Superblock evaluation team (2019). "Changing the Urban Design of Cities for Health: The Barcelona Superblock Model. Under review.

Case Study 2 → Transportation and Health: Burden of Disease Analysis of Traffic Noise and Vehicle Crashes in Houston, Texas

Aim and Study Setting

- Estimate preventable premature mortality in Houston attributable to:
  - Noise levels > 30 dB Lden
  - Motor vehicle crashes
- Houston area residents (30 to 75 years old) (N=2,045,368) on the projected census tract level (N=592)

Method

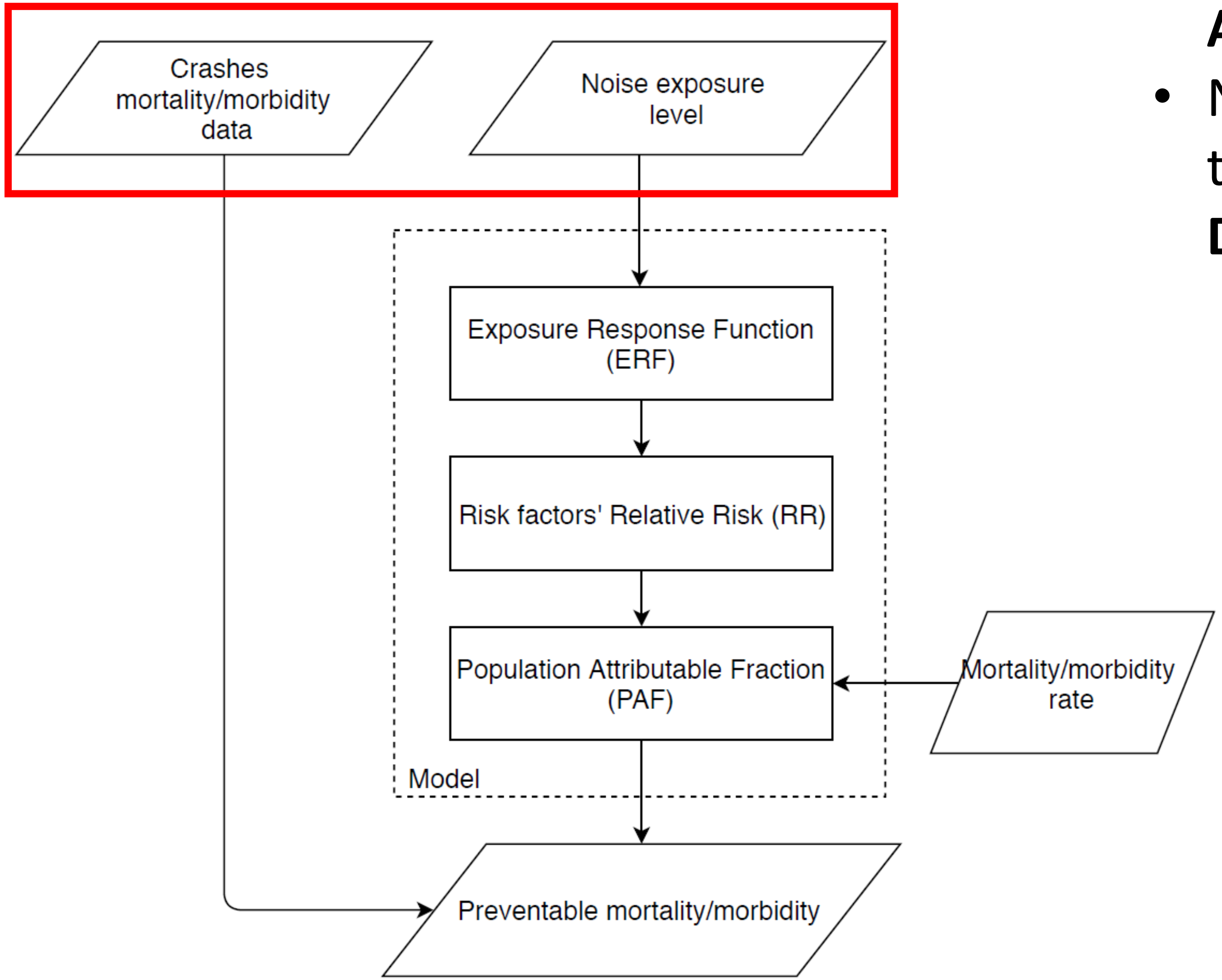


Figure. The methodological framework

- Roadway crash fatalities in Houston extracted from the **National Highway Traffic Safety Administration dataset** (2016)
- Noise exposures extracted from the national transportation noise maps from **US Department of Transportation** (Lden) (2014)
  - Road noise
  - Aviation noise

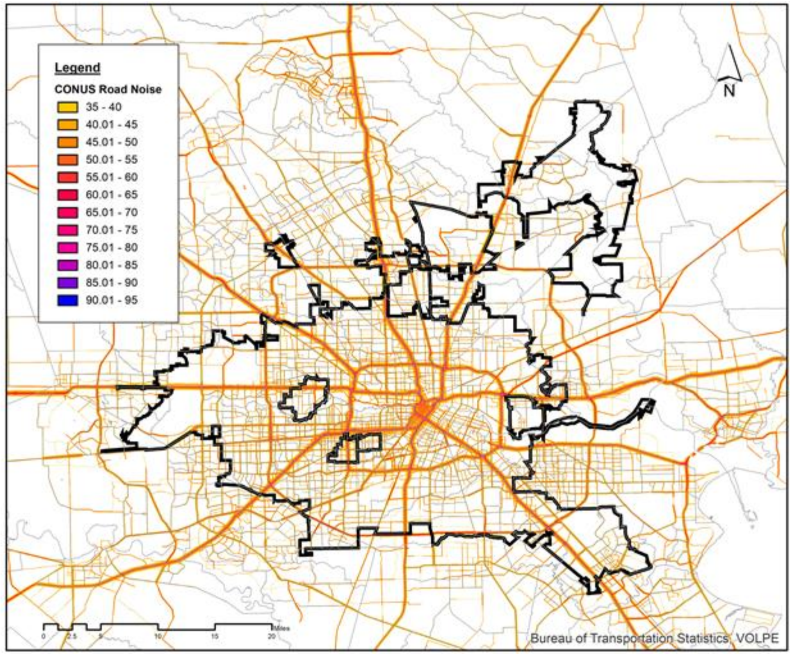


Figure. Road noise levels in Houston

Method

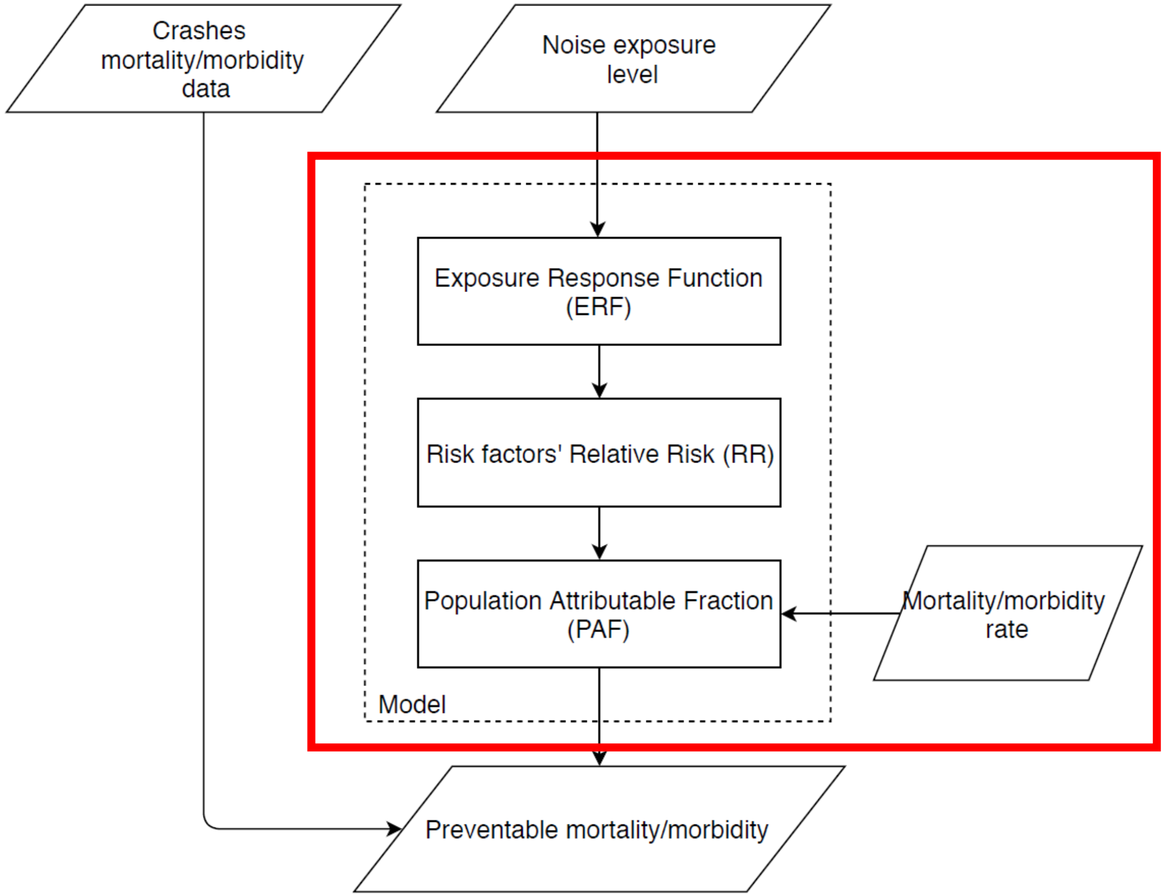
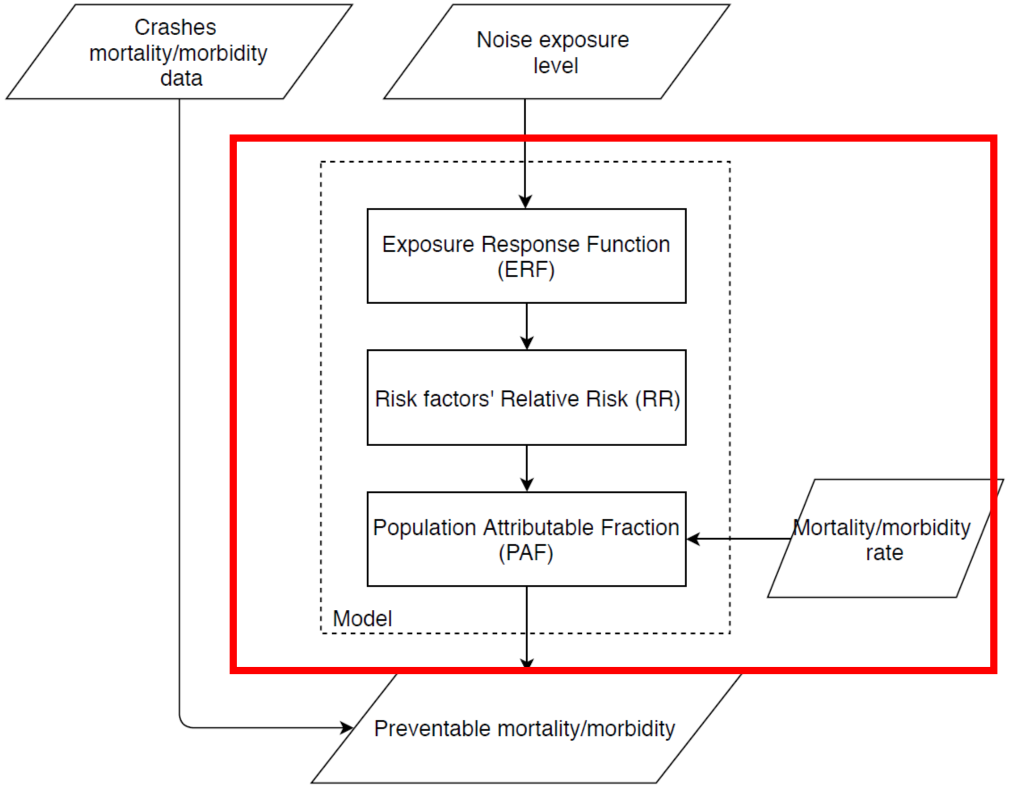


Figure. The methodological framework

- ERF extracted from Héritier et al. (2017)
  - HR (95% CI) for *all CVD causes of death* (ICD-10 = I00-I99) per 10 dB increase in **Lden Road** = 1.025 (1.018–1.032)
  - HR (95% CI) for **Myocardial Infarction** (ICD-10 = I21-I22) per 10 dB increase in **Lden Aviation** = 1.027 (1.006–1.049)
  - HR (95% CI) for **Hear Failure** (ICD-10 = I50) per 10 dB increase in **Lden Aviation** = 1.056 (1.028–1.085)
  - Adjusted for sex, neighborhood index of SES, civil status, education level, mother tongue, nationality and annual NO_2 exposure

CI = Confidence Interval
CVD = Cardiovascular disease
NO_2 = Nitrogen Dioxide
SES = Socioeconomic Status

Method



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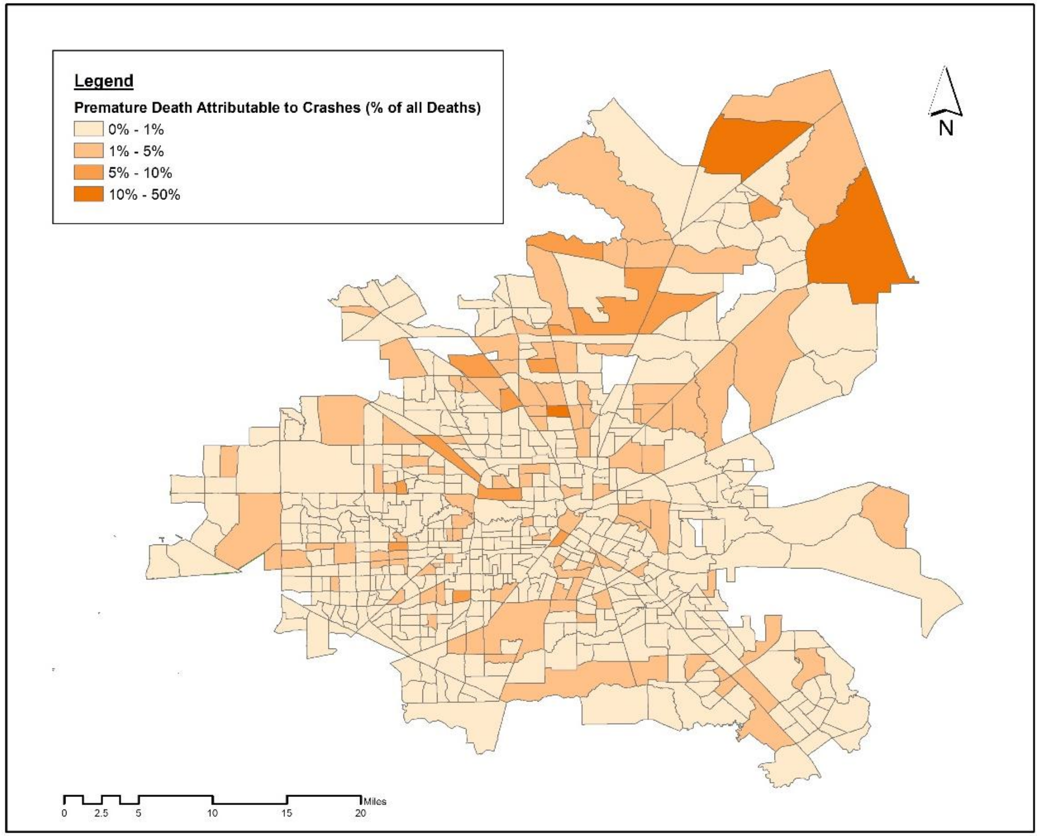
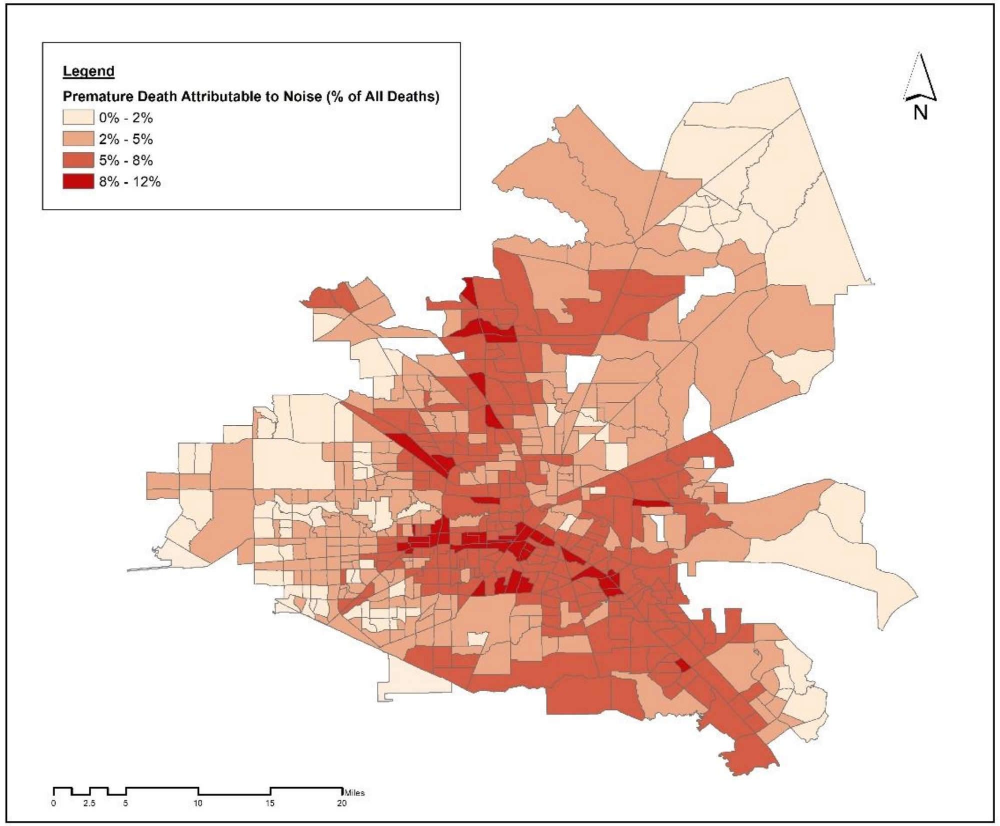
  - Adjusted for sex, neighborhood index of SES, civil status, education level, mother tongue, nationality and annual NO2 exposure
- Mortality data extracted from the Centers for Disease Control (CDC) at the county matched to outcomes by ICD-10 codes, and restricted to >30 and <= 75 years old (2016)
- There is no risk of premature mortality for noise levels below 30 dB


Legend
Premature Death Attributable to Crashes (% of all Deaths)
0% - 1%
1% - 5%
5% - 10%
10% - 50%
N
0 2.5 5 10 15 20 Miles


Legend
Premature Death Attributable to Noise (% of All Deaths)
0% - 2%
2% - 5%
5% - 8%
8% - 12%
N
0 2.5 5 10 15 20 Miles

Results

Results

Results under review – contact Haneen for more information

Sohrabi, Soheil and **Khreis**, Haneen (2019). “Transportation and Public Health: Burden of Disease Analysis of Traffic Noise and Vehicle Crashes in Houston, Texas”. Under review.

Conclusions

14 pathways that link mobility to health

Differing levels of evidence for the different pathways

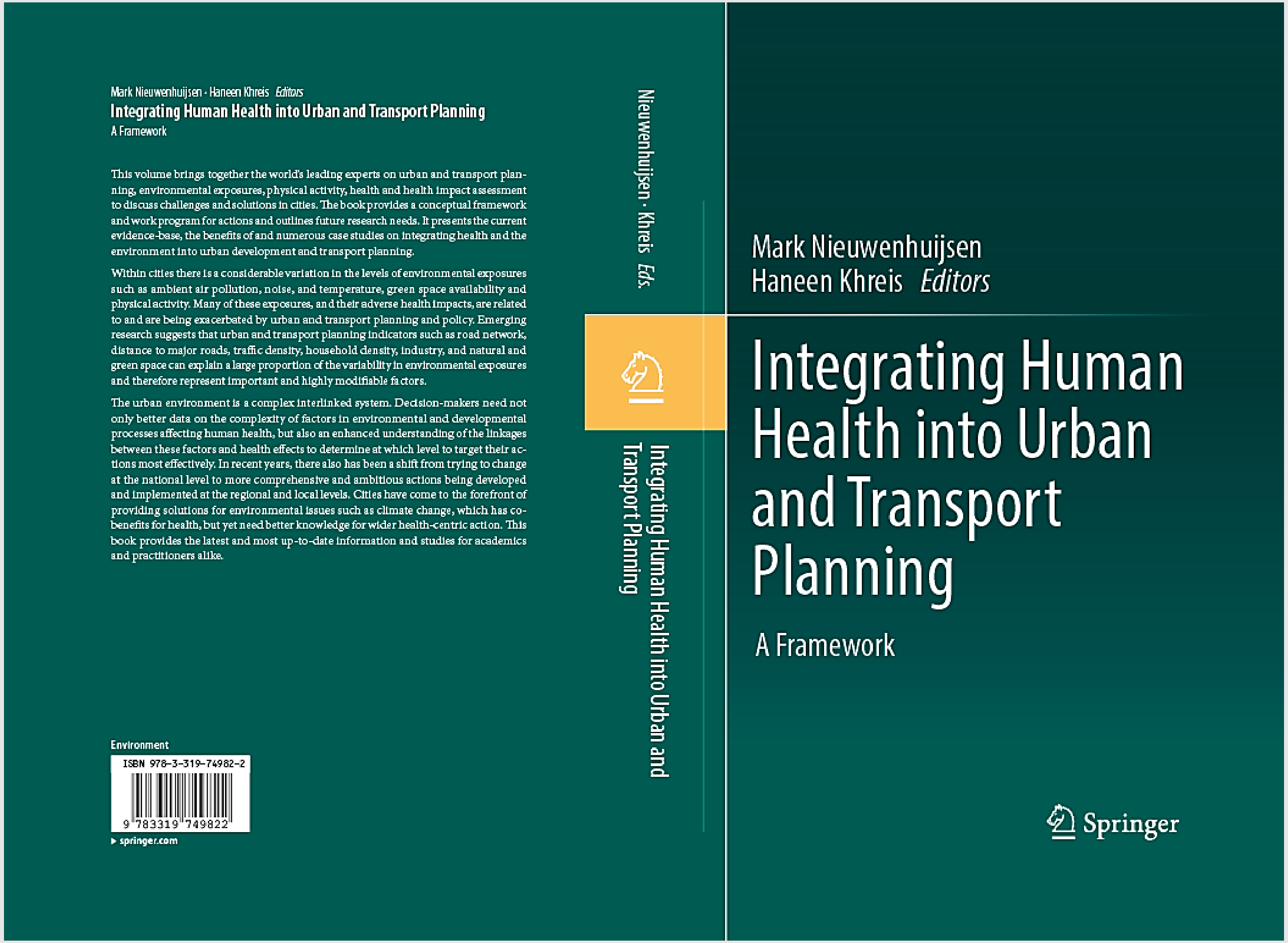
Pathways will be impacted by the introduction of AVs or similar technologies

The health impacts of the pathways are very context, population and policy specific

Transferability of policy and technology is complex and needs careful consideration

There is no research quantifying the burden of disease of AVs implementation

AVs = Autonomous vehicles



Contact information

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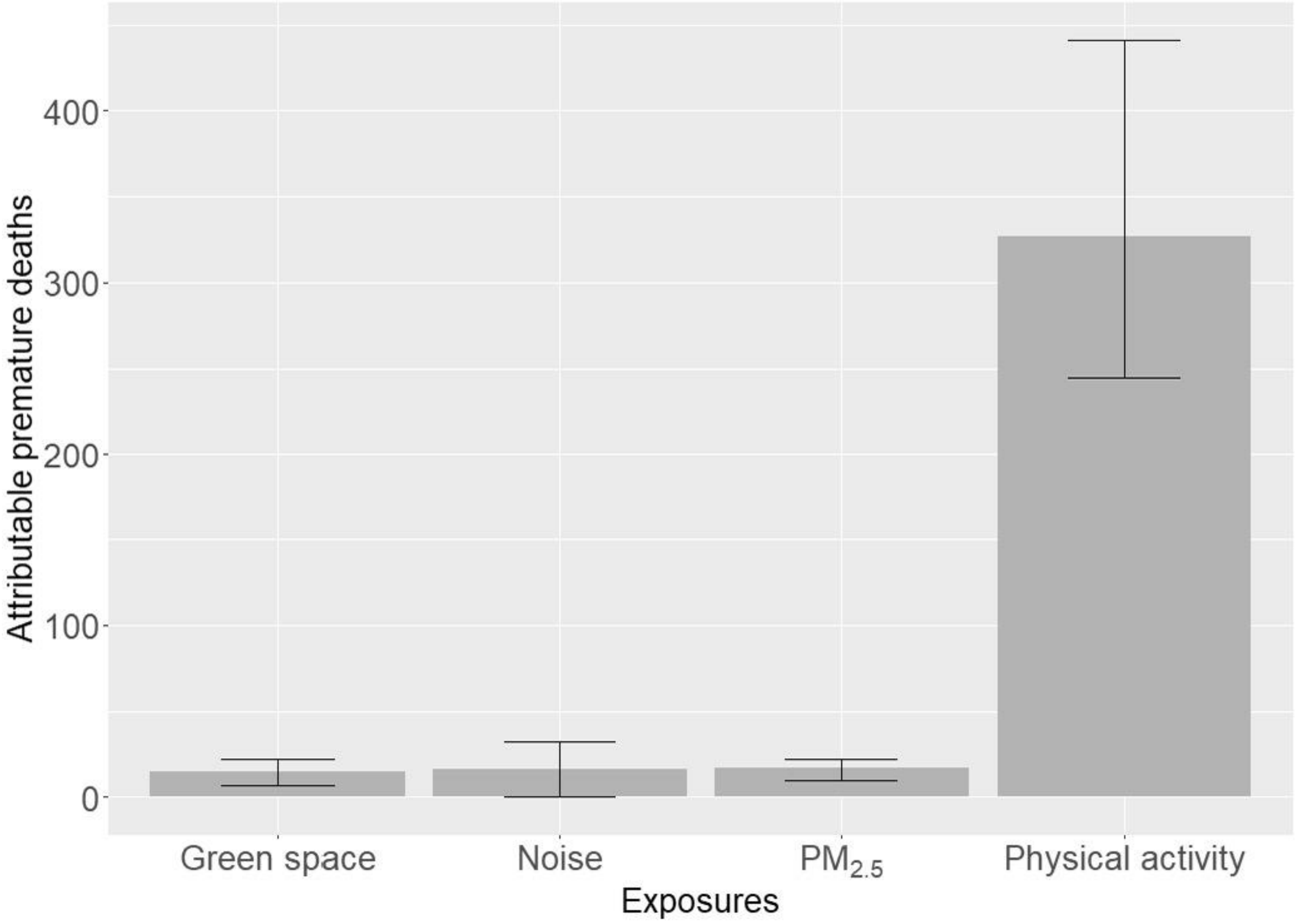
BACK-UP SLIDES

Results - Attributable Premature Mortality

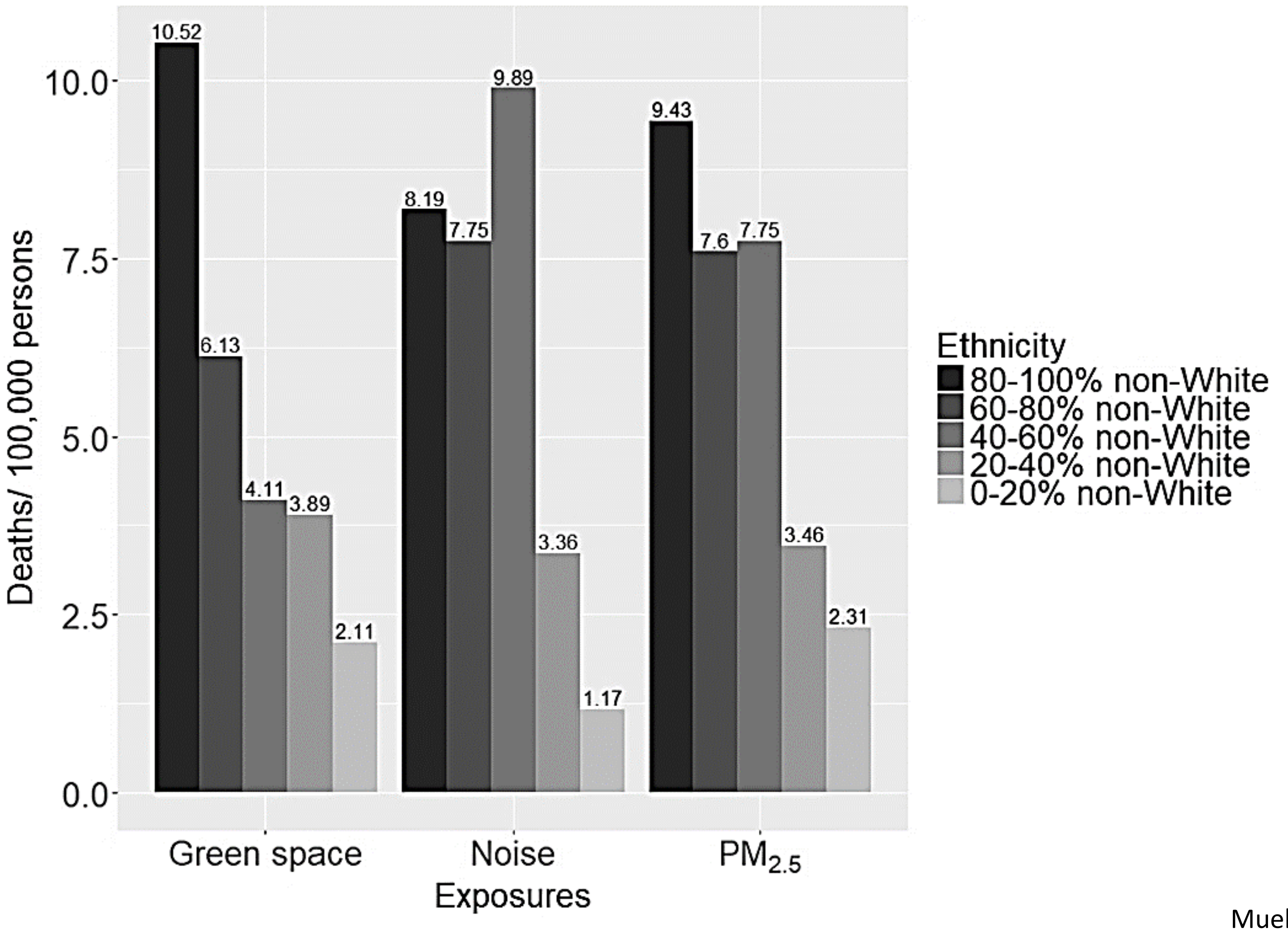


375 annual premature deaths (95% CI: 276 - 474) could be preventable by **compliance with international recommendations**:

- Physical activity → 327 deaths
- Air pollution → 17 deaths
- Green space → 16 deaths
- Noise → 15 deaths

Bradford Case Study

Mueller, Natalie, David Rojas-Rueda, Haneen Khreis, Marta Cirach, Carles Milà, Ana Espinosa, Maria Foraster et al. "Socioeconomic inequalities in urban and transport planning related exposures and mortality: A health impact assessment study for Bradford, UK." Environment international 121 (2018): 931-941.



BY ETHNICITY

Mueller, Natalie, David Rojas-Rueda, Haneen Khreis, Marta Cirach, Carles Milà, Ana Espinosa, Maria Foraster et al. "Socioeconomic inequalities in urban and transport planning related exposures and mortality: A health impact assessment study for Bradford, UK." Environment international 121 (2018): 931-941.