Substitution of car trips by active transport in 6 European cities: A health impact assessment

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6 European cities

Barcelona

Basel

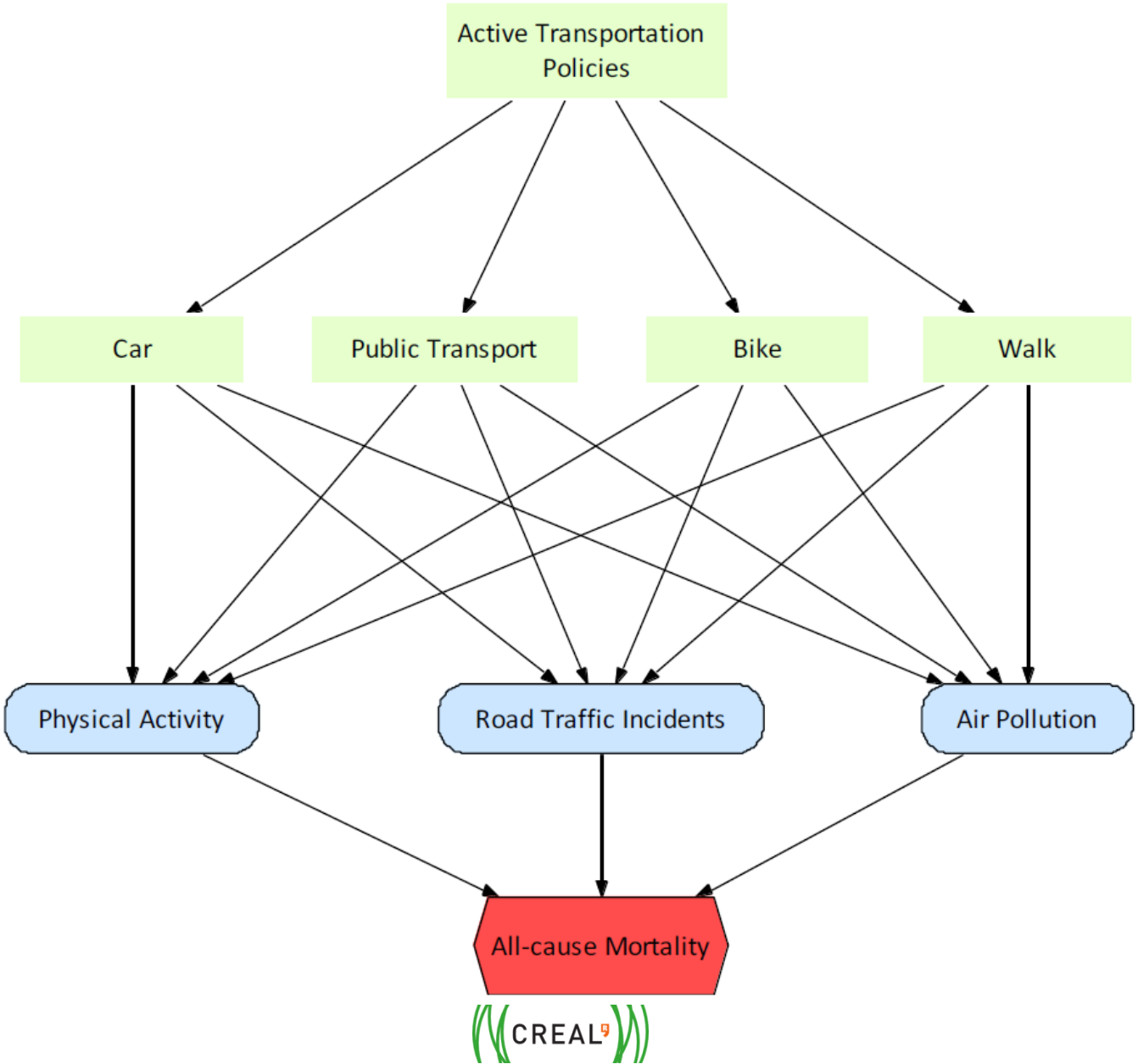
Copenhagen

Paris

Prague

Warsaw

CONCEPTUAL FRAMEWORK



SCENARIOS

Scenarios	Description
A	Attaining the levels of cycling of the city of *Copenhagen* (35% of all trips made by bicycle)
B	Attaining the levels of walking of the city of *Paris* (50% of all trips made by walking)

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CHARACTERISTICS OF CITIES

Variable		Barcelona	Basel	Copenhagen	Paris	Prague	Warsaw
Population in the city		1,620,943	164,516	559,440	2,249,977	1,246,786	1,715,517
All trips per day	*PT*	*1,484,788*	*443,900*	*303,333*	*2,027,880*	*1,860,517*	*2.520.225*
	Walk	*2,302,569*	*608,808*	*520,615*	*2,819,239*	*888,383*	*997.820*
	Bicycle	*109,282*	*265,186*	*492,805*	*162,147*	*9,737*	*54.818*
	Car	*457,095*	*429,320*	*491,576*	*731,482*	*932,643*	*1.278.847*
Trips per person per day	All modes	3·1	3·4	3·2	3·4	2·9	3
Average distance travelled per trip (km)	*PT*	*10·0**	*13·1*	*2·8**	*7·6*	*15·7*	*28.6*
	Walk	*1·4**	*1·3*	*0·7**	*1·1*	*1·2*	*1·1*
	Bicycle	*3·3**	*2·9*	*3·7**	*3·4*	*4·4*	*5·4*
	Car	*8·9**	*9·5*	*5·1**	*11·4*	*10·1*	*20.3*
Average trip duration (minutes)	PT	33·2	44·4	9·3	35·0	33·4	44·0
	Walk	16·2	24·0	9·9	14·0	16·1	17·0
	Bicycle	14·0	14·9	14·0	20·0	29·0	24·0
	Car	24·4	22·8	11·3	28·0	27·9	32·0
Average speed (km/h)	*PT*	*18·1*	*17·7**	*18·1*	*8·4*	*28·2*	*39·0*
	Walk	*5·0*	*3·3**	*4·2*	*4·4*	*4·5*	*3·8*
	Bicycle	*14·0*	*11·6**	*16·0*	*13·4*	*12·0*	*13·4*
	Car	*21·8*	*25·0**	*27·0*	*21·7*	*45·0*	*38·0*

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CHARACTERISTICS OF CITIES

Variable		Barcelona	Basel	Copenhagen	Paris	Prague	Warsaw
Road traffic fatalities per year, 16-64 years (Deaths/year)	PT	0·0	0·0	0·0	0·0	0·2	2·8
	Walk	11·2	2·0	3·8	16·6	27·6	48·5
	Bicycle	0·2	1·2	2·3	2·7	0·6	2·5
	Car	3·1	0·9	4·6	3·4	5·8	18·8
Concentration of $PM_{2·5}$ ($\mu g/m^3$)	*City annual average*	*15·6*	*13·6*	*11·0*	*18·0*	*21·0*	*23·6*
	Car	*35·5*	*30·9*	*25·0*	*41·0*	*47·8*	*53·7*
	Bicycle	*35·0*	*30·5*	*24·7*	*40·4*	*47·1*	*52·9*
	PT	*25·9*	*22·6*	*18·3*	*29·9*	*34·9*	*39·2*
	Walk	*21·6*	*18·8*	*15·2*	*24·9*	*29·1*	*32·7*
Expected mortality (deaths/1000 inhabitants)	16-64 years	2·05	2·64	2·22	2·73	2·90	3·70
Deaths per billion of kilometre travelled	*PT*	*0·00**	*0·00**	*0·00**	*0·00**	*0·02**	*0·11**
	Walk	*12·87**	*9·14**	*28·53**	*19·08**	*70·45**	*122·48**
	Bicycle	*2·30**	*5·63**	*3·42**	*13·61**	*33·05**	*23·31**
	Car	*2·79**	*0·79**	*5·04**	*1·66**	*1·07**	*1·99**

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METHODS

Data sources:

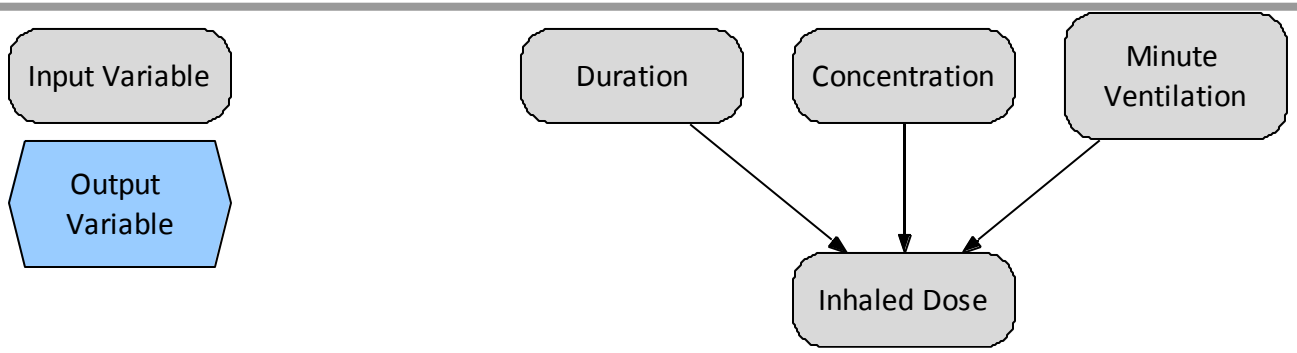
- Health records.
- Travel surveys.
- Environmental records.

TAPAS model:

- Analytica 4.2 (Lumina Decisions Systems, CA)

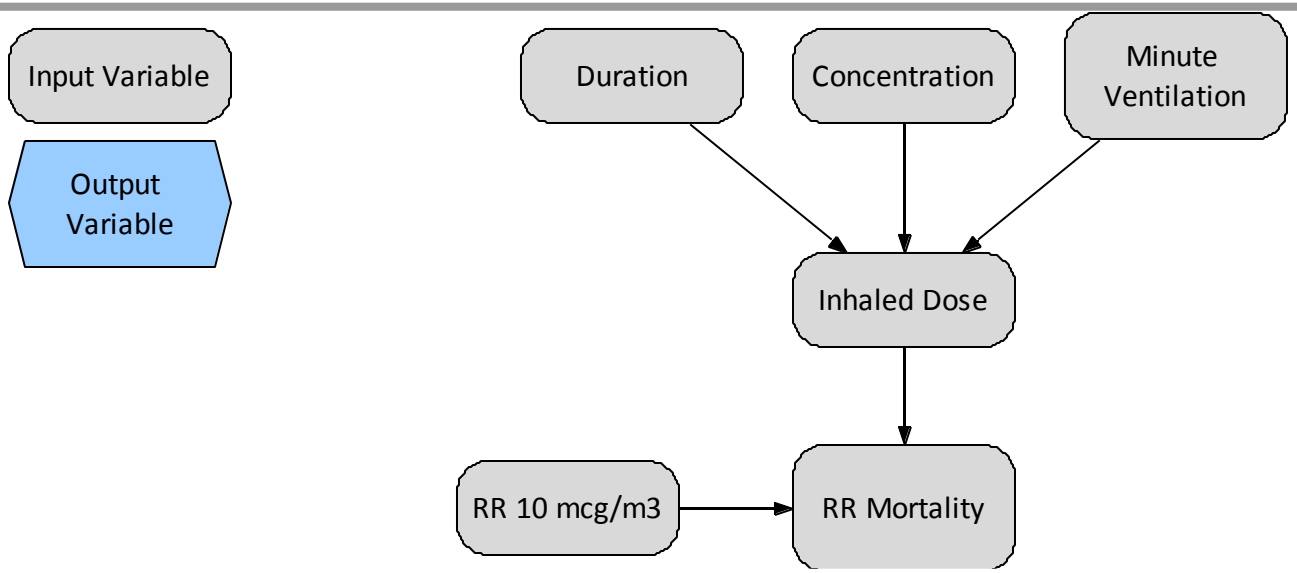
  Quantitative decision model software, based on Monte Carlo simulations.

AIR POLLUTION



RR: Relative Risk of all-cause mortality.
RR10: average adjusted relative risk of all-caused mortality for a 10μg/m3 change of pollutant.
AFexp: Attributable fraction among exposed; BCN: Barcelona;

AIR POLLUTION



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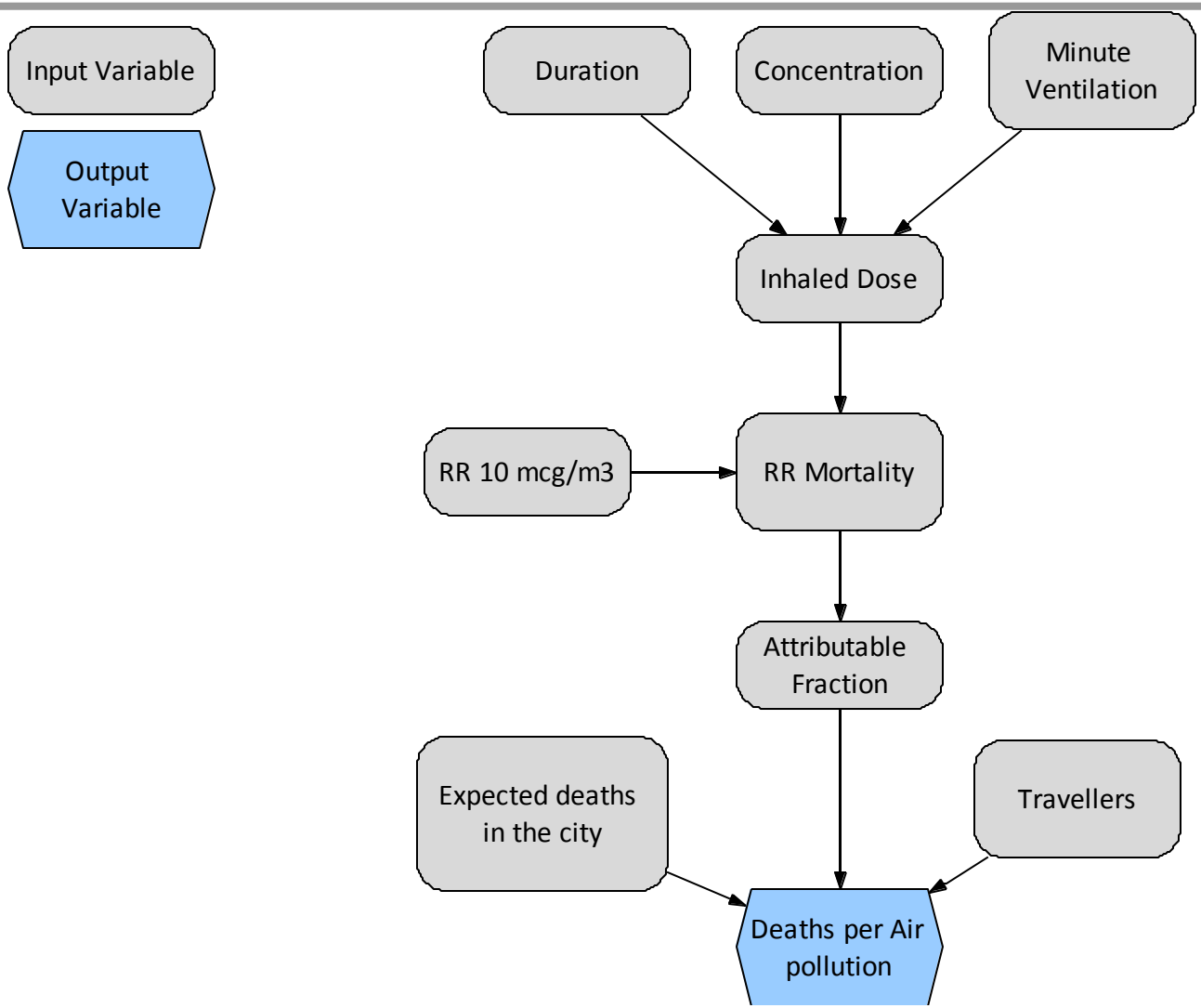

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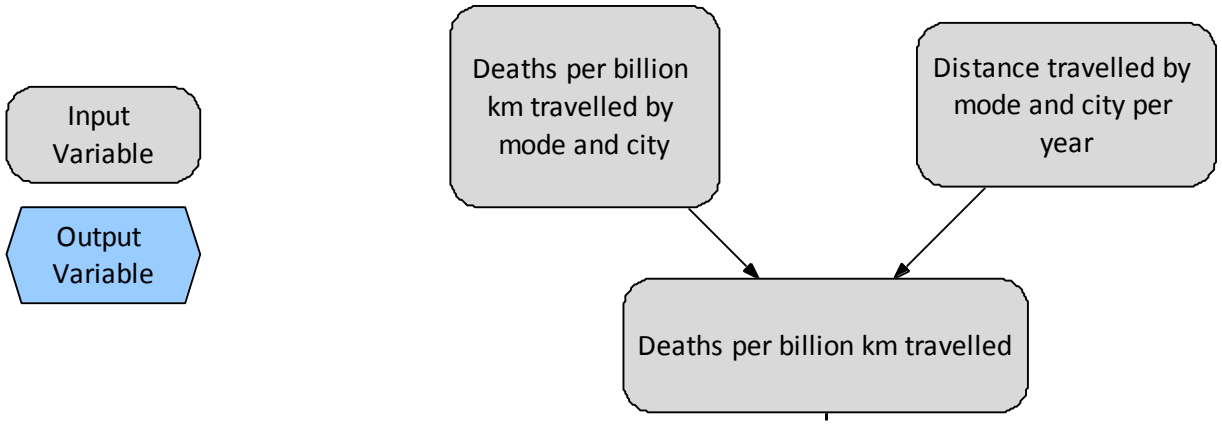
AIR POLLUTION

	PM2.5 concentration (μg/m3)	Minute ventilation (m3/hr)	Activity duration (hr)	Inhaled dose in each activity (μg)	Total dose in a day (μg)
Sleeping	19	0.27	8	41	
Resting	19	0.27	15	79	
Car	46	0.27	0.19	2.47	**169**
Metro	57	0.27	0.13	2.1	171
Bus	21.1	0.27	0.29	1.7	169
Walking	19.8	1.3	0.25	6.81	**104**
Bicycling	29.5	2.2	0.33	21	**179**

TRAFFIC INCIDENTS



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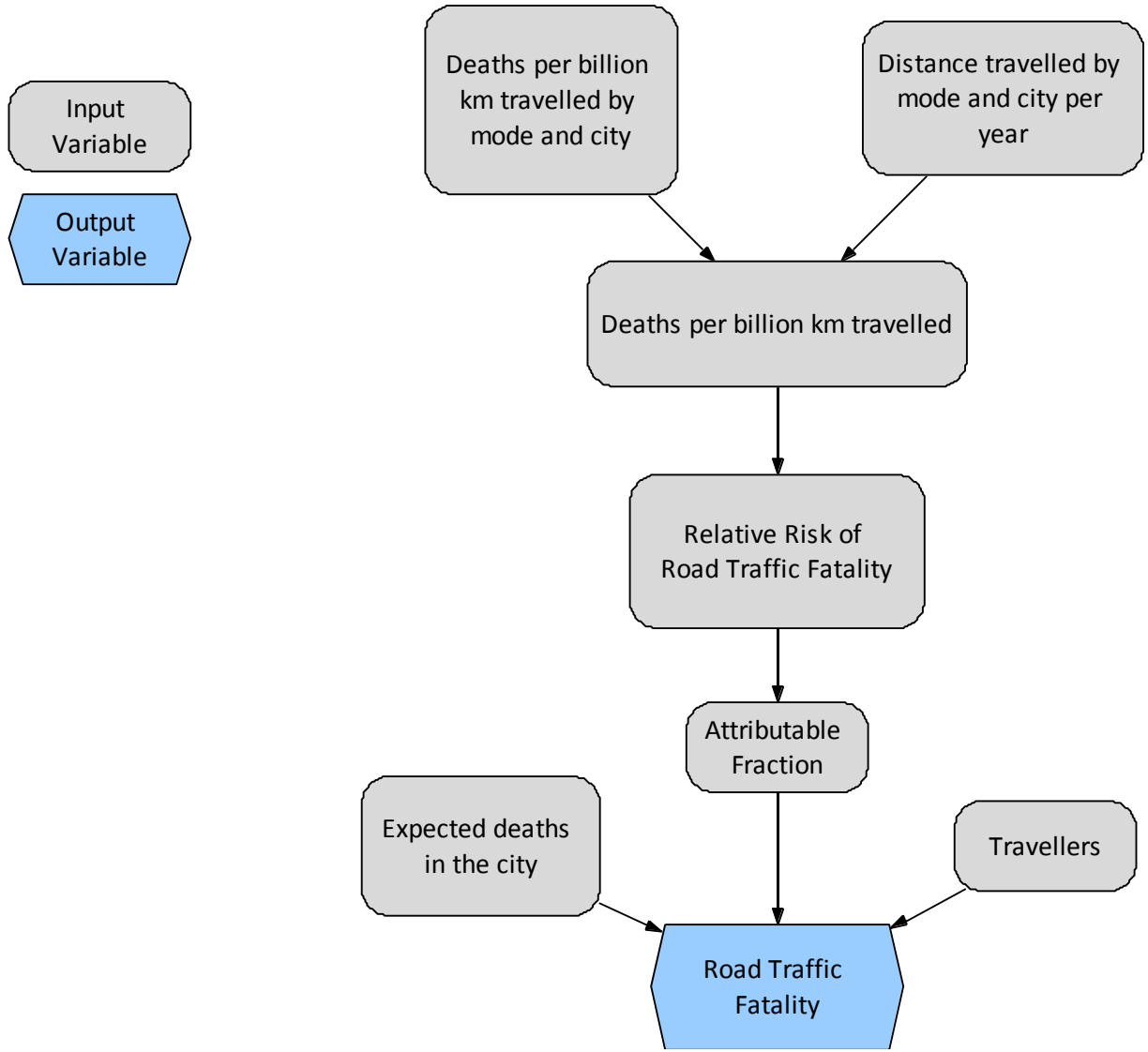

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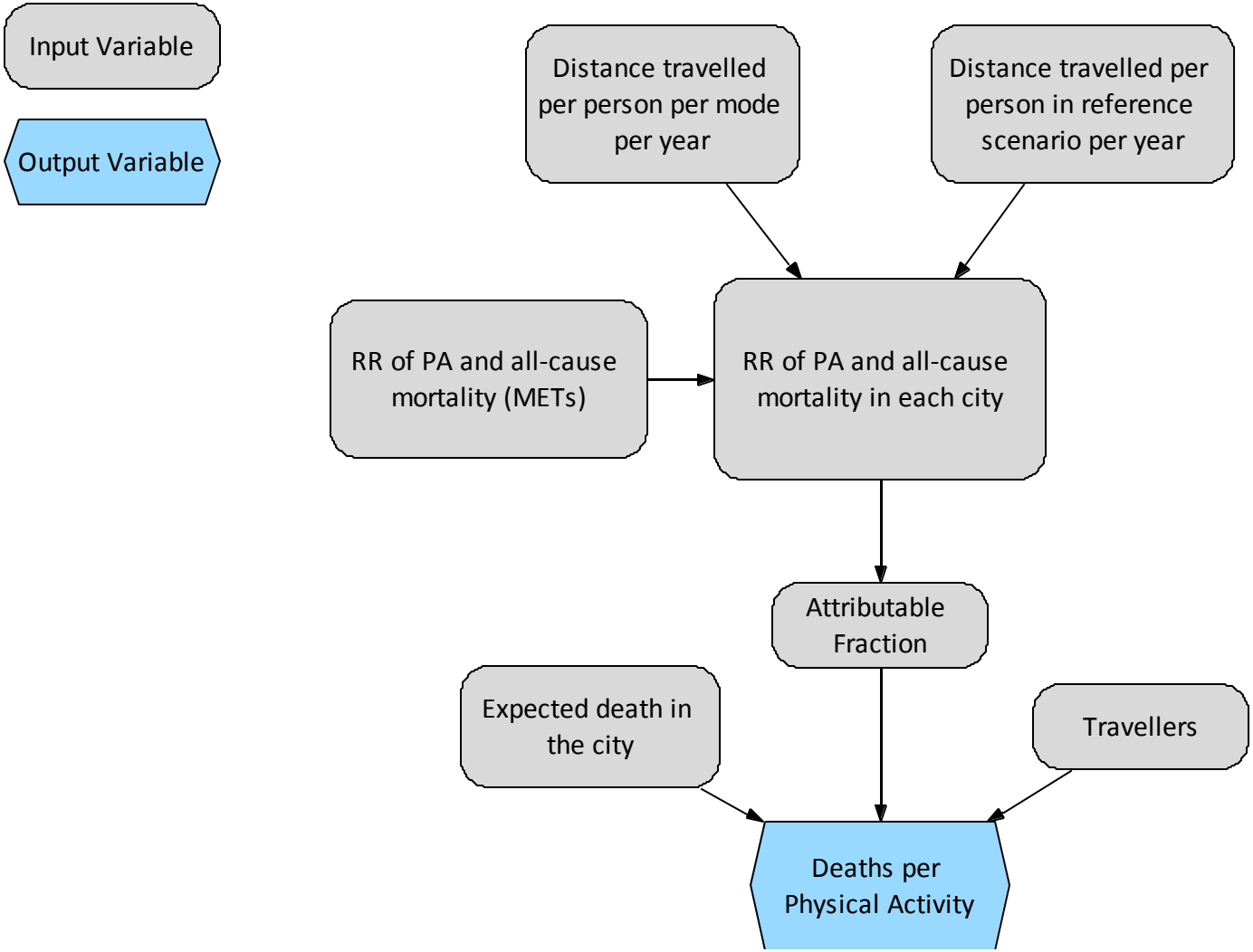
PHYSICAL ACTIVITY



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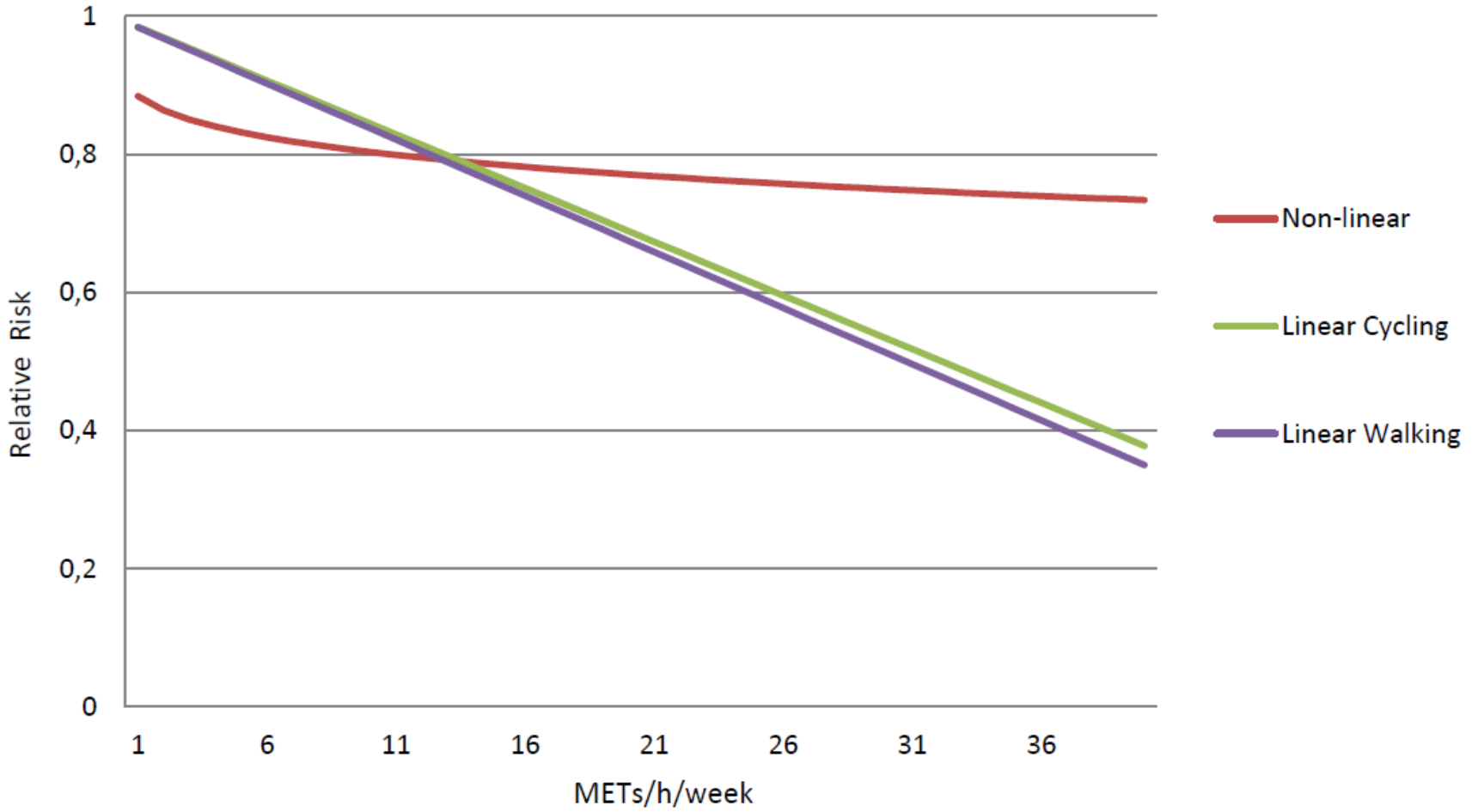
CURVILINEAR DOSE RESPONSE FUNCTION FOR PA



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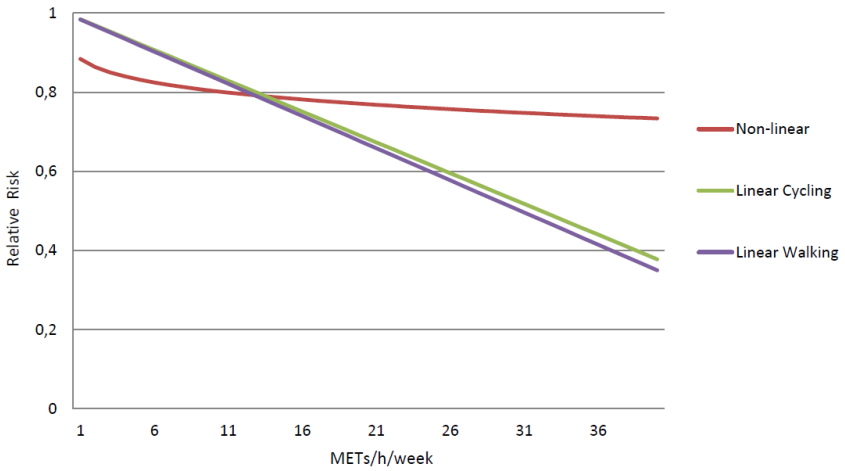


Table 4. Percentages of basal levels of physical activity by sex and age reported in Switzerland.

		Man				Woman			
Physical activity levels	**METs/H/w**	15-34 years	35-49 years	50-64 years	=> 65 years	15-34 years	35-49 years	50-64 years	=> 65 years
Trained	45	43	27	23	23	30	23	23	13
Regular active	37·5	37	43	50	50	43	43	43	47
Partially active	15	13	20	17	13	20	20	20	17
Inactive	0	7	10	10	13	7	13	13	23

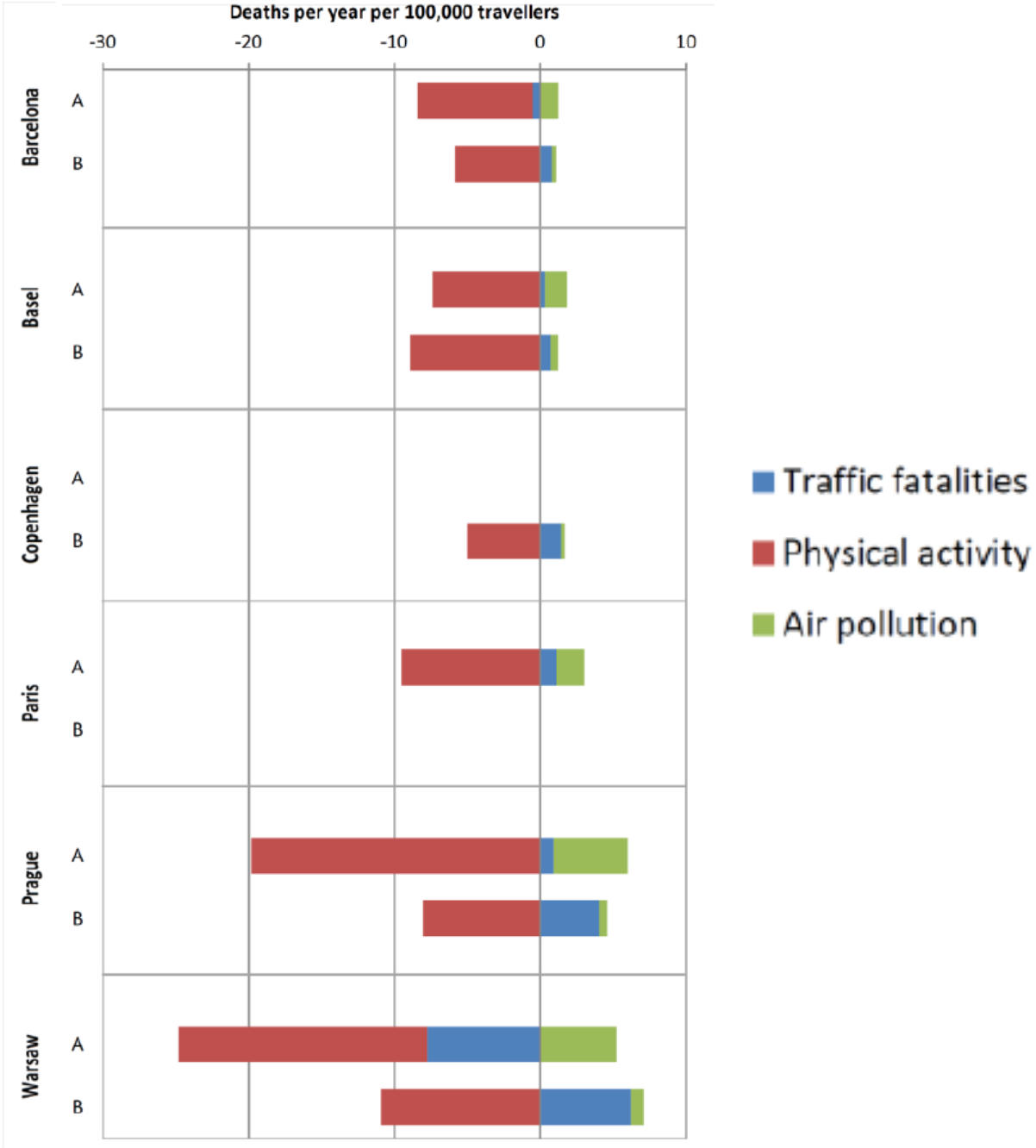
ANNUAL ESTIMATED DEATHS

Scenario		Barcelona	Basel	Copenhagen	Paris	Prague	Warsaw
A	35% of all trips by bicycles	-37·8 (-24, -56)	-5·7 (-3, -9)	-	-37·4 (-18, -64)	-61·0 (-29, -104)	-113·4 (-76, -163)
B	50% of all trips walking	-3·0 (-2, -4)	-6·2 (-4, -9)	-3·9 (-2, -6)	-	-11·3 (-3, -21)	-19·8 (-3, -42)

ANNUAL ESTIMATED DEATHS

Scenario		Barcelona	Basel	Copenhagen	Paris	Prague	Warsaw
A	35% of all trips by bicycles	-37·8 (-24, -56)	-5·7 (-3, -9)	-	-37·4 (-18, -64)	-61·0 (-29, -104)	-113·4 (-76, -163)
B	50% of all trips walking	-3·0 (-2, -4)	-6·2 (-4, -9)	-3·9 (-2, -6)	-	-11·3 (-3, -21)	-19·8 (-3, -42)
Results by each 100,000 travellers who shifted modes (new cyclists or pedestrians).							
A	Cyclist increment	-7·1 (-4, -10)	-5·5 (-3, -9)	-	-6·5 (-3, -11)	-13·8 (-6, -23)	-19·6 (-13, -28)
B	Pedestrian increment	-4·7 (-3, -7)	-7·7 (-5, -11)	-3·1 (-1, -5)	-	-3·4 (-1, -6)	-3·8 (-1, -8)

CREAL


Deaths per year per 100,000 travellers
-30
-20
-10
0
10
Barcelona
A
B
Basel
A
B
Copenhagen
A
B
Paris
A
B
Prague
A
B
Warsaw
A
B
Traffic fatalities
Physical activity
Air pollution

SENSITIVITY ANALYSIS

LINEAR DRF FOR PHYSICAL ACTIVITY

Scenario	Barcelona	Basel	Copenhagen	Paris	Prague	Warsaw
Main result						
A	-7·1 (-4, -10)	-5·5 (-3, -9)	-	-6·5 (-3, -11)	-13·8 (-6, -23)	-19·6 (-13, -28)
B	-4·7 (-3, -7)	-7·7 (-5, -11)	-3·1 (-1, -5)	-	-3·4 (-1, -6)	-3·8 (-1, -8)
Sensitivity analysis (applying linear dose response function for physical activity)						
A	-43·6 (-26, -78)	-62·4 (-28, -93)	-	-102·2 (-34, -124)	-60·4 (-56, -112)	-180·1 (-74, -225)
B	-28·3 (-1, -62)	-121·7 (-4, -166)	-29·4 (-1, -65)	-	-27·2 (2, -73)	-45·4 (3, -153)

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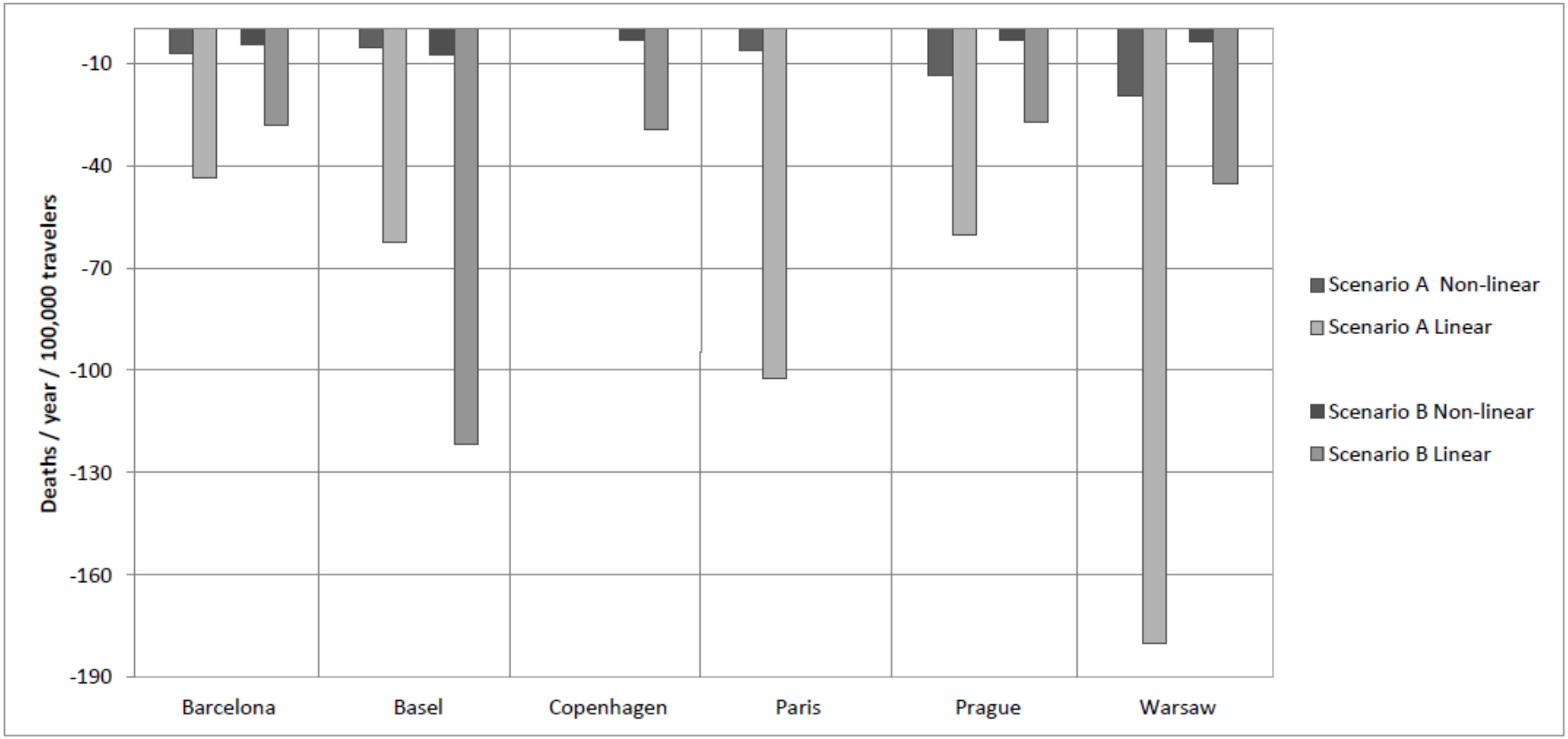
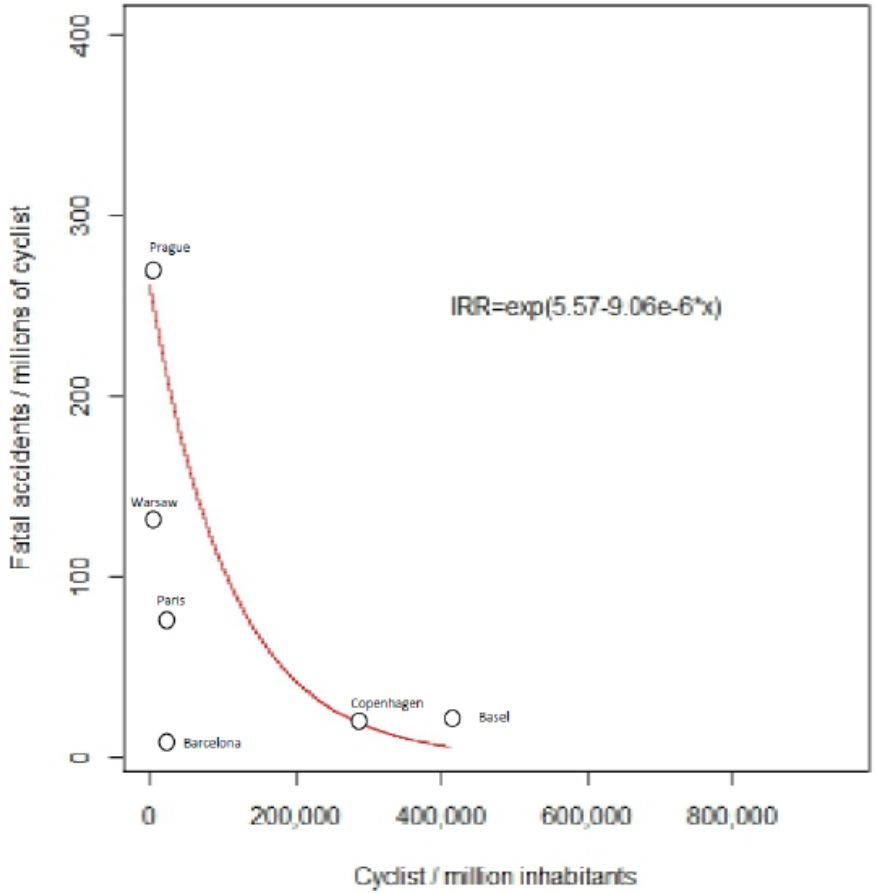
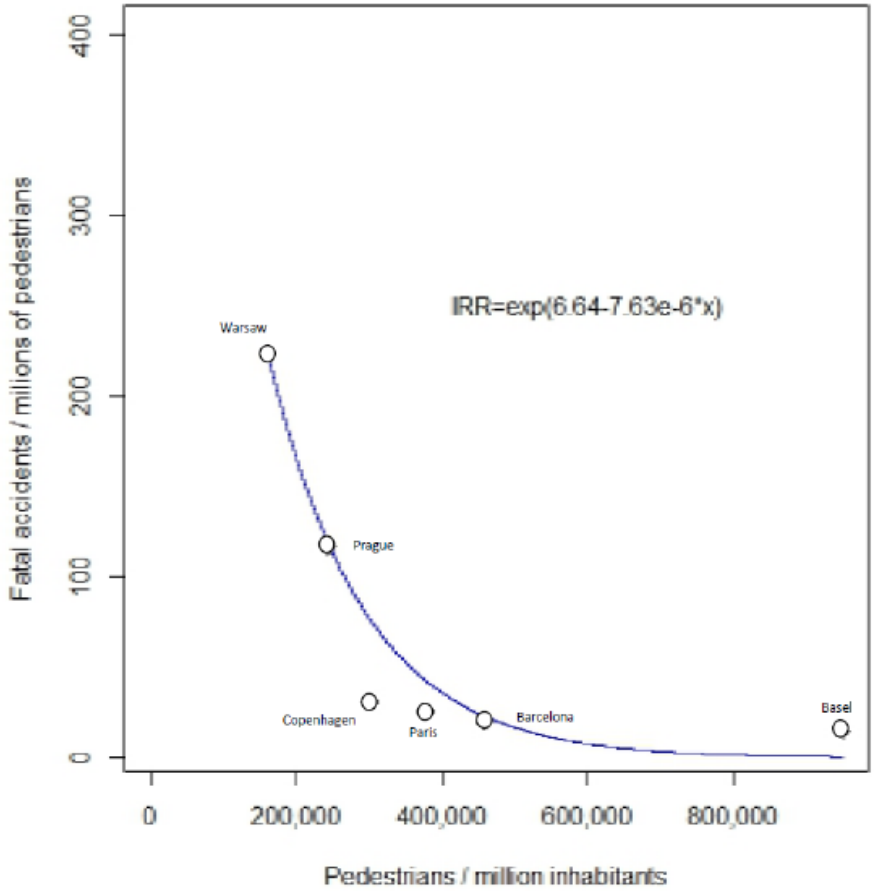
LINEAR DRF FOR PHYSICAL ACTIVITY



SAFETY IN NUMBERS APPROACH





SAFETY IN NUMBERS APPROACH

Scenario	Barcelona	Basel	Copenhagen	Paris	Prague	Warsaw
Main result						
A	-7·1 (-4, -10)	-5·5 (-3, -9)	-	-6·5 (-3, -11)	-13·8 (-6, -23)	-19·6 (-13, -28)
B	-4·7 (-3, -7)	-7·7 (-5, -11)	-3·1 (-1, -5)	-	-3·4 (-1, -6)	-3·8 (-1, -8)
Sensitivity analysis (applying "safety in numbers" approach)						
A	-7·4 (-4, -11)	-6·3 (-3, -9)	-	-8·1 (-4, -12)	-20·8 (-13, -30)	-24·3 (-18, -33)
B	-4·9 (-3, -7)	-8·3 (-5, -12)	-4·2 (-2, -6)	-	-6·1 (-3, -9)	-8·9 (-5, -13)

USING ESCAPE RR FOR PM2.5

Scenario	Barcelona	Basel	Copenhagen	Paris	Prague	Warsaw
Main result						
A	-7·1 (-4, -10)	-5·5 (-3, -9)	-	-6·5 (-3, -11)	-13·8 (-6, -23)	-19·6 (-13, -28)
B	-4·7 (-3, -7)	-7·7 (-5, -11)	-3·1 (-1, -5)	-	-3·4 (-1, -6)	-3·8 (-1, -8)
Sensitivity analysis (applying ESCAPE dose response function)						
A	-5·6 (-1, -10)	-3·8 (1, -9)	-	-4·0 (1, -11)	-7·5 (6, -23)	-13·1 (0 , -28)
B	-4·4 (-2, -7)	-7·1 (-3, -11)	-3·0 (-1, -5)	-	-2·7 (0, -6)	-2·7 (1, -8)

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CONCLUSIONS

- *Active transport polices* can produce health benefits.
- Most of the benefits derived from *physical activity*.
- *City characteristics* determine the magnitude of the impact.
- Collaboration of *health practitioners, transport specialists and urban planners*.

BMJ

BMJ 2011;343:d4521 doi: 10.1136/bmj.d4521

RESEARCH

The health risks and benefits of cycling in urban environments compared with car use: health impact assessment study

Environment International 49 (2012) 100–109

Contents lists available at SciVerse ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Replacing car trips by increasing bike and public transport in the greater Barcelona metropolitan area: A health impact assessment study

Preventive Medicine 57 (2013) 573–579

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Health impact assessment of increasing public transport and cycling use in Barcelona: A morbidity and burden of disease approach

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Thank you

TAPAS partners:

de Nazelle A
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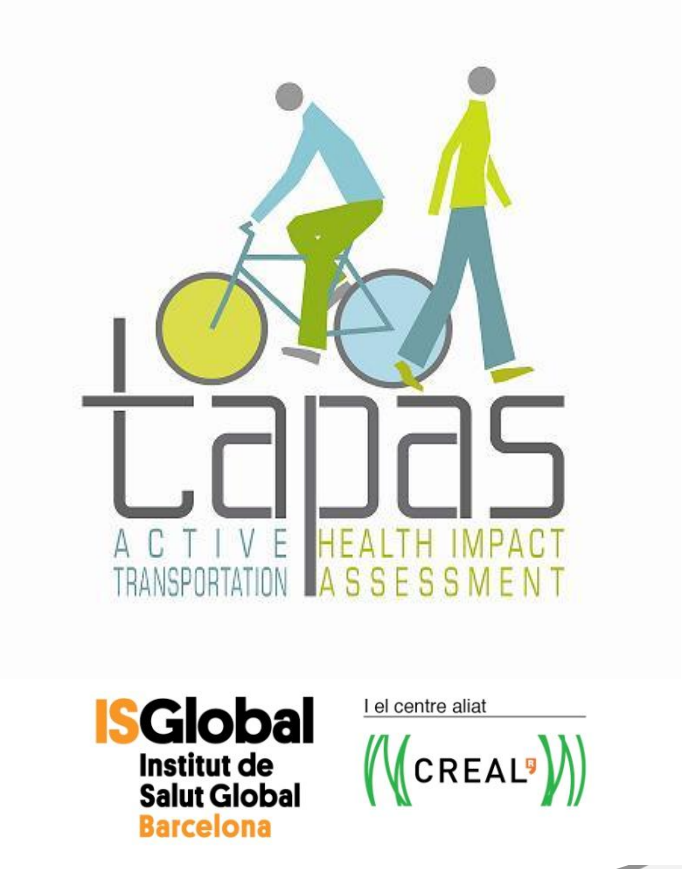
Andersen ZJ
Braun-Fahrländer C
Bruha J
Bruhova-Foltynova H
Desqueyroux H
Praznoczy C
Ragettli S. M
Tainio M



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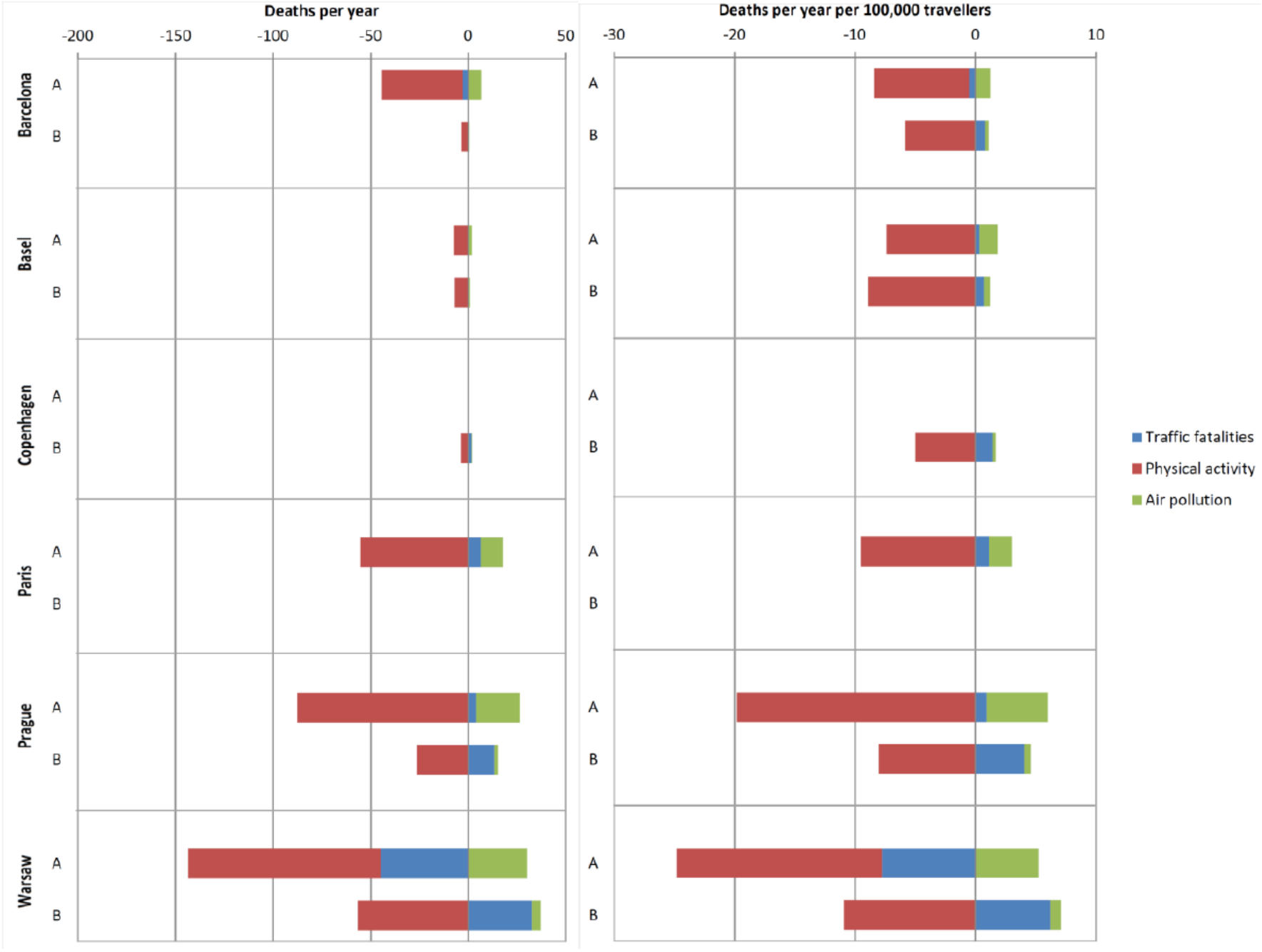
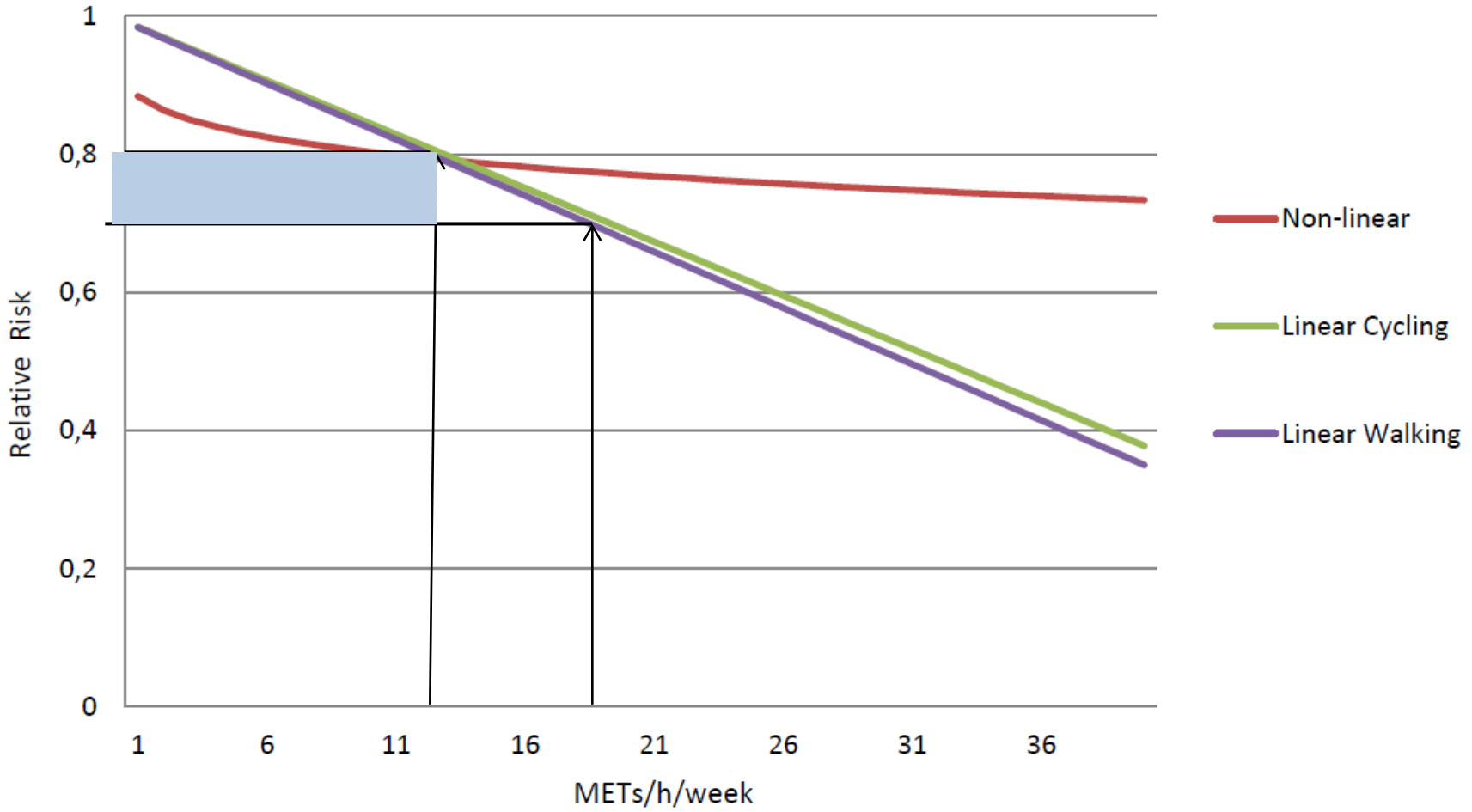
CENTER FOR RESEARCH IN ENVIRONMENTAL EPIDEMIOLOGY
CREAL - BARCELONA


Deaths per year
-200
-150
-100
-50
0
50
Deaths per year per 100,000 travellers
-30
-20
-10
0
10
Barcelona
Basel
Copenhagen
Paris
Prague
Warsaw
A
B
Traffic fatalities
Physical activity
Air pollution

CO2 EMISSIONS AVOIDED ANNUALLY (METRIC TONES/ YEAR)

Scenario		Barcelona	Basel	Copenhagen	Paris	Prague	Warsaw
A	35% of all trips by bicycles	22,957	2,503	-	19,923	22,819	26,423
B	50% of all trips walking	1,139	2,088	2,745	-	8,320	11,611

CURVILINEAR DOSE RESPONSE FUNCTION FOR PA



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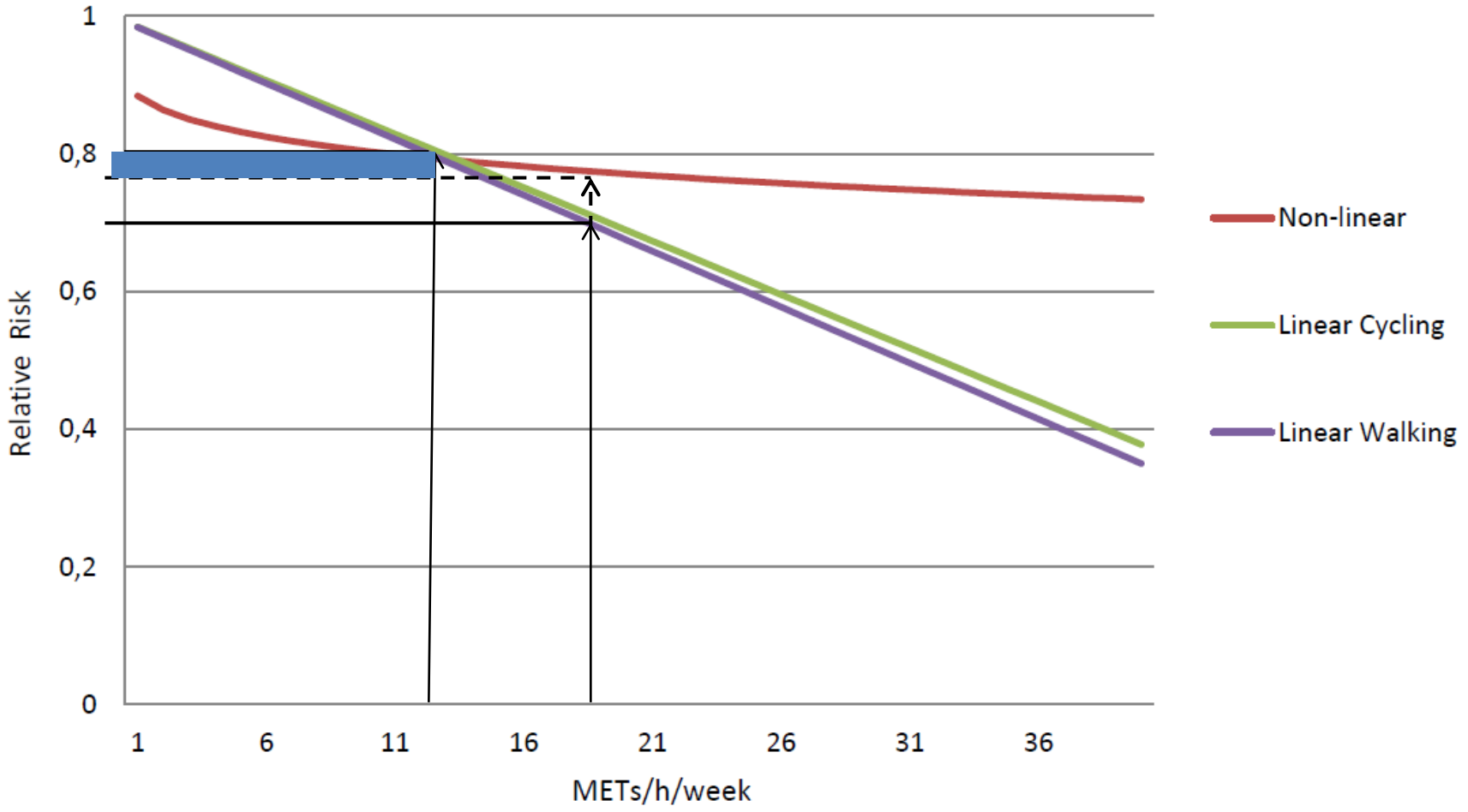

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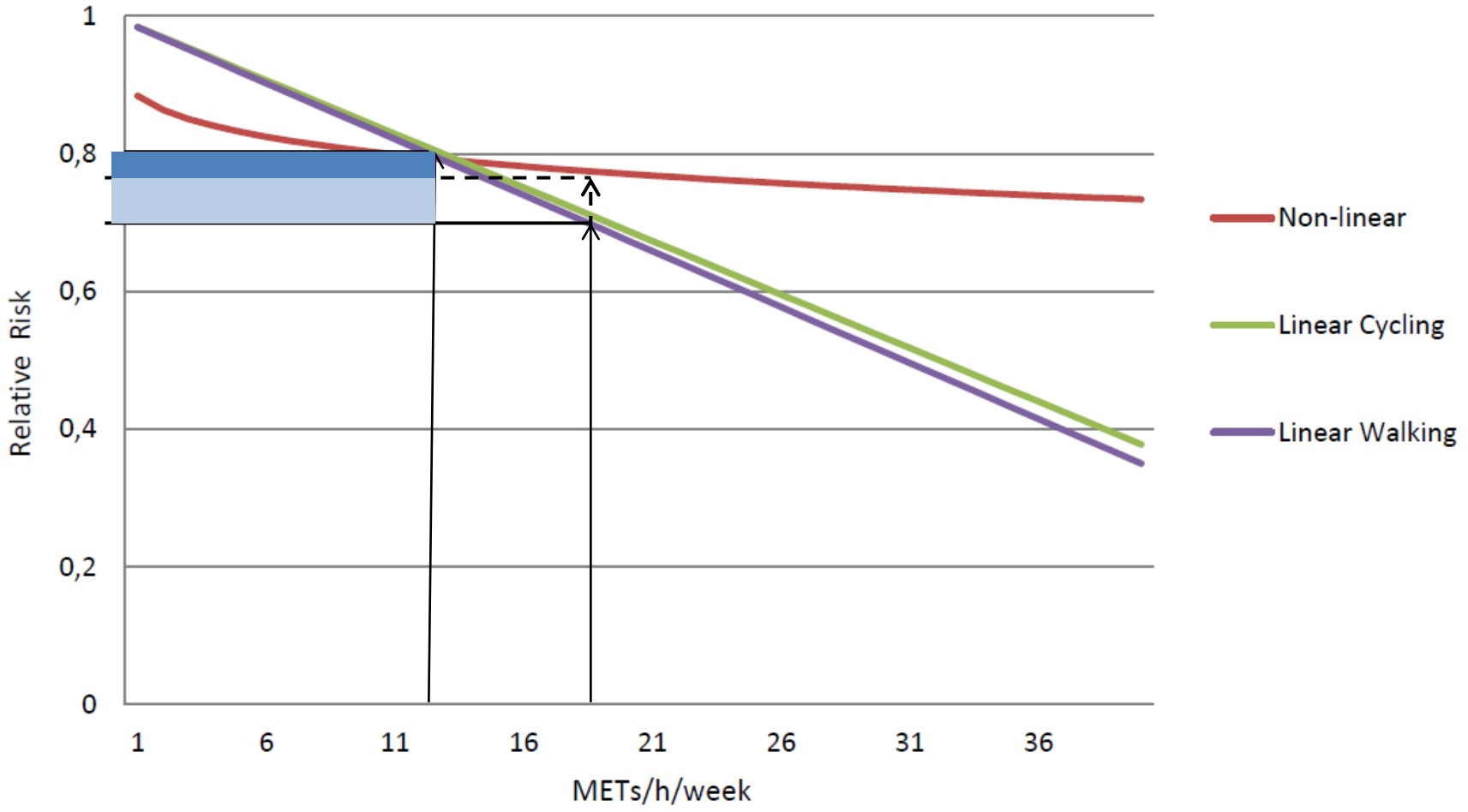


SCENARIOS

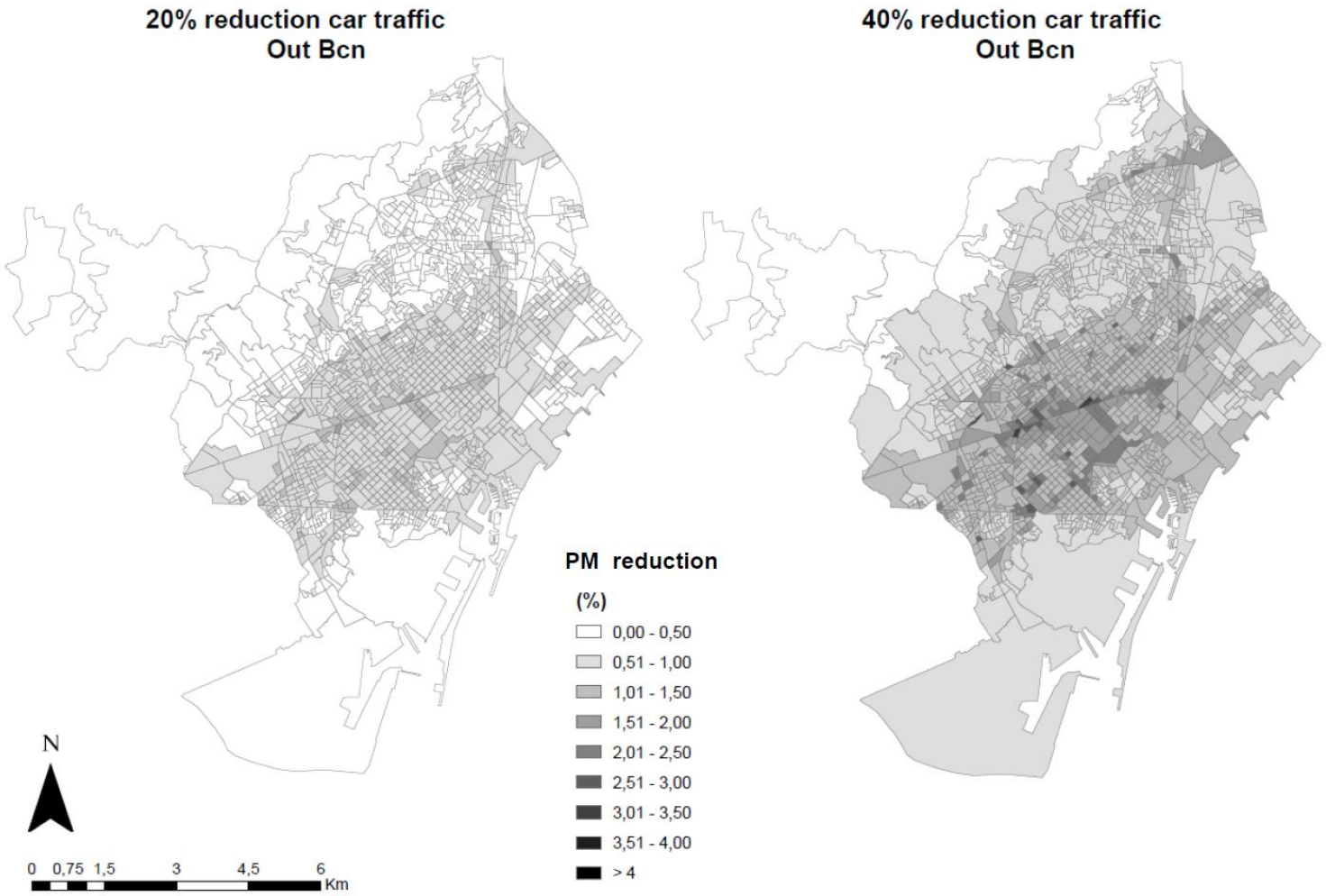
Scenario	Description	Assumptions
A	Attaining the levels of cycling of the city of Copenhagen (35% of all trips in the city are made by bicycle)	50% of the trips coming from PT trips 40% of the trips coming from Walk trips 10% of the trips coming from Cars trips
B	Attaining the levels of walking of the city of Paris (50% of all trips in the city are made walked)	75% of the trips coming from PT trips* 1% of the trips coming from Bicycle trips* 24% of the trips coming from Cars trips*

50% OF TRIPS COMING FROM CARS

Scenario	Barcelona	Basel	Copenhagen	Paris	Prague	Warsaw
Main result						
A	-7·1 (-4, -10)	-5·5 (-3, -9)	-	-6·5 (-3, -11)	-13·8 (-6, -23)	-19·6 (-13, -28)
B	-4·7 (-3, -7)	-7·7 (-5, -11)	-3·1 (-1, -5)	-	-3·4 (-1, -6)	-3·8 (-1, -8)
Sensitivity analysis (applying 50% of car trips substitution by bicycling or walking)						
A	-15·2 (-10, -22)	-13·2 (-8, -20)	-	-13·2 (-8, -21)	-23·7 (-13, -39)	-31·4 (-20, -47)
B	-8·8 (-6, -12)	-10·8 (-7, -16)	-6·5 (-4, -10)	-	-9·1 (-5, -14)	-11·6 (-7, -19)

Scenario A: 35% of all trips by bicycle; Scenario B: 50% of all trips walking.

Reduction in PM (Urban Air-Dispersion Model)

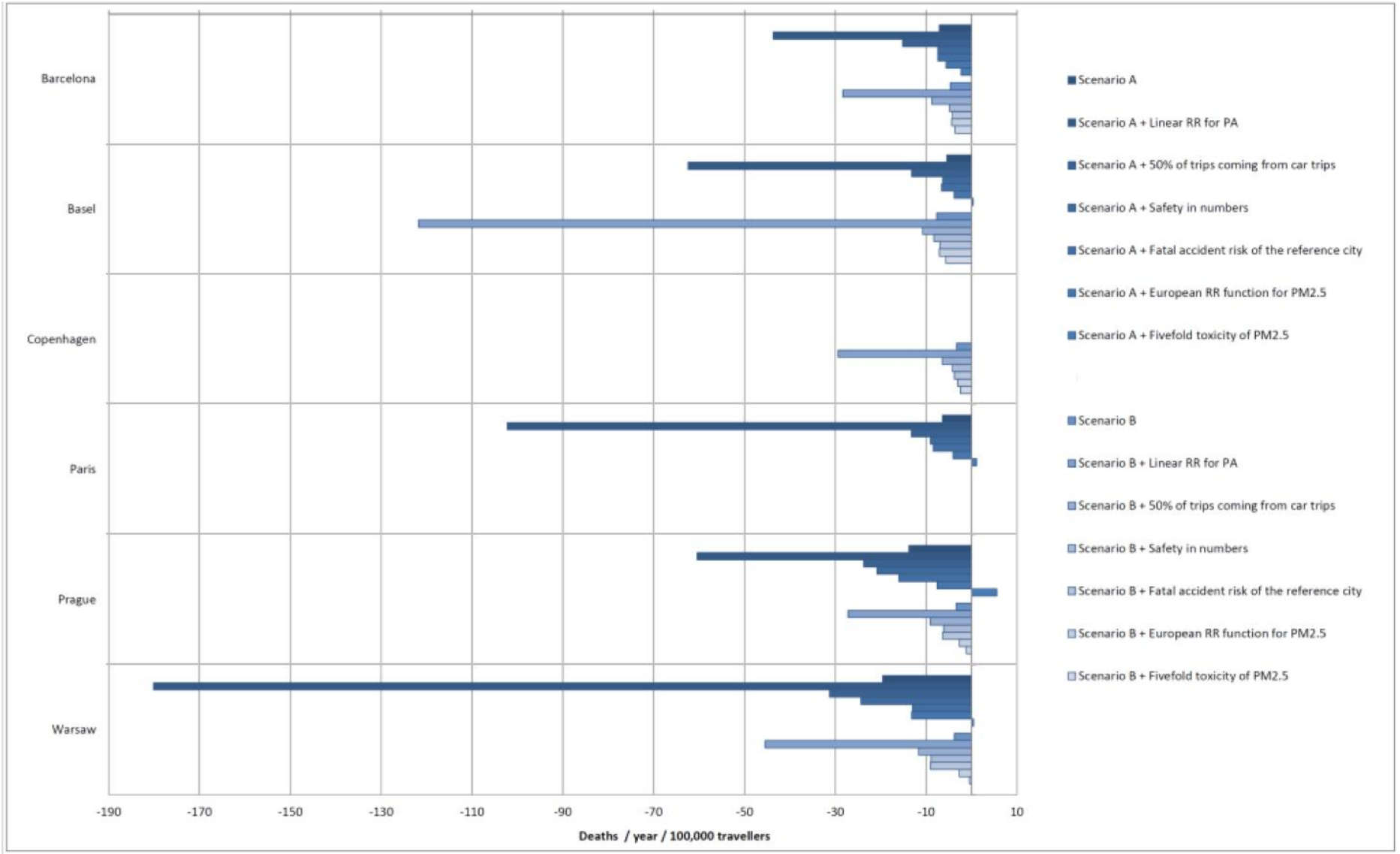


Percentage of car trips reduction	PM 2.5 [a]				CO_2 [b]
	Reduction ($\mu g/m^3$) [c]	Percentage of reduction (%) [d]	Deaths (deaths/year)	Days gained in life expectancy [e]	Emissions avoided (ton/year) [f]
Inside Barcelona [g]					
20%	0.07	0.32	-5	1.14	21,391
40%	0.14	0.64	-10.03	2.28	42,783
Outside Barcelona [h]					
20%	0.13	0.58	-9.06	2.05	80,233
40%	0.26	1.16	-18.15	4.11	160,467

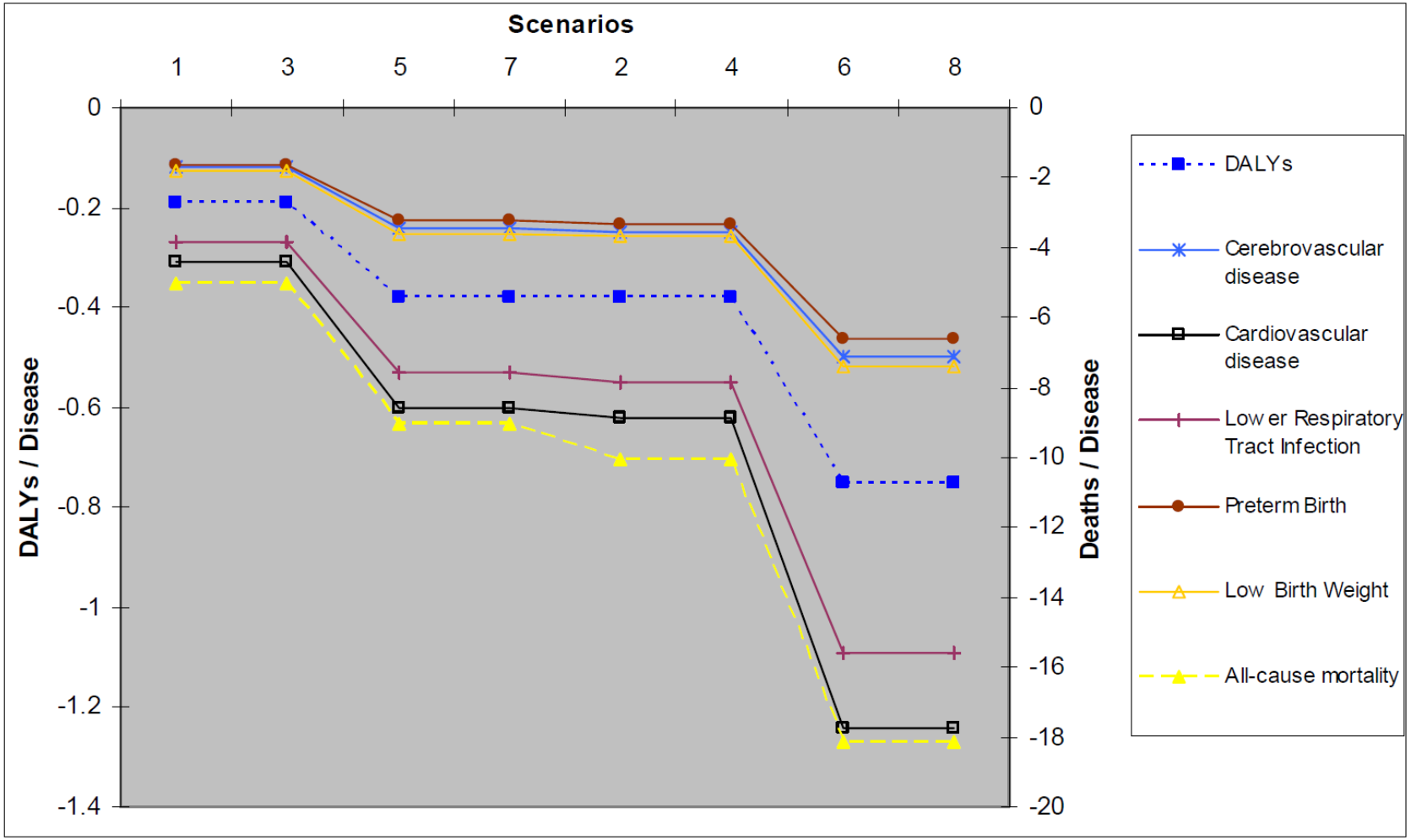
APPLYING DEATH RATE/KM TRAVELED OF REFERENCE CITY

Scenario	Barcelona	Basel	Copenhagen	Paris	Prague	Warsaw
Main result						
A	-7·1 (-4, -10)	-5·5 (-3, -9)	-	-6·5 (-3, -11)	-13·8 (-6, -23)	-19·6 (-13, -28)
B	-4·7 (-3, -7)	-7·7 (-5, -11)	-3·1 (-1, -5)	-	-3·4 (-1, -6)	-3·8 (-1, -8)
Sensitivity analysis (applying deaths rate per km travelled of reference city)						
A	-7·4 (-5, -11)	-6·6 (-4, -10)	-	-8·4 (-5, -13)	-16·0 (-8, -25)	-12·9 (-6, -21)
B	-4·2 (-2, -7)	-6·9 (-4, -10)	-3·8 (-2, -5)	-	-6·3 (-4, -9)	-9·1 (-6, -13)

ANNUAL ESTIMATED DEATHS



DEATHS, DISEASE OR DALYS PER YEAR RELATED TO AP IN GP.



5 FOLD GREATER TOXICITY (PM2.5)

Scenario	Barcelona	Basel	Copenhagen	Paris	Prague	Warsaw
Main result						
A	-7·1 (-4, -10)	-5·5 (-3, -9)	-	-6·5 (-3, -11)	-13·8 (-6, -23)	-19·6 (-13, -28)
B	-4·7 (-3, -7)	-7·7 (-5, -11)	-3·1 (-1, -5)	-	-3·4 (-1, -6)	-3·8 (-1, -8)
Sensitivity analysis (applying 5 fold times more toxicity of PM2·5)						
A	-2·2 (1, -7)	0·3 (4, -5)	-	1·1 (6, -5)	5·5 (18, -10)	0·4 (12, -14)
B	-3·6 (-1, -6)	-5·7 (-2, -10)	-2·4 (-1, -4)	-	-1·1 (1, -5)	-0·5 (3, -5)

Scenario A: 35% of all trips by bicycle; Scenario B: 50% of all trips walking.

Scenario		Barcelona	Basel	Copenhagen	Paris	Prague	Warsaw
A·1	35% of all trips by bicycles	-37·8	-8·7	-	-42·6	-64·0	-137·1
A·2	50% of all trips walking	-3·0	-9·6	-4·6	-	-7·1	-8·8
B·1	20% reduction of car trips	-5·9	-7·6	-6·9	-11·6	-16·4	-28·5
B·2	50% reduction of car trips	-14·9	-19·2	-17·3	-29·1	-41·1	-71·4