Overall health impacts of a potential increase in active commuting in Stockholm, Sweden

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Sustainable health

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Aim

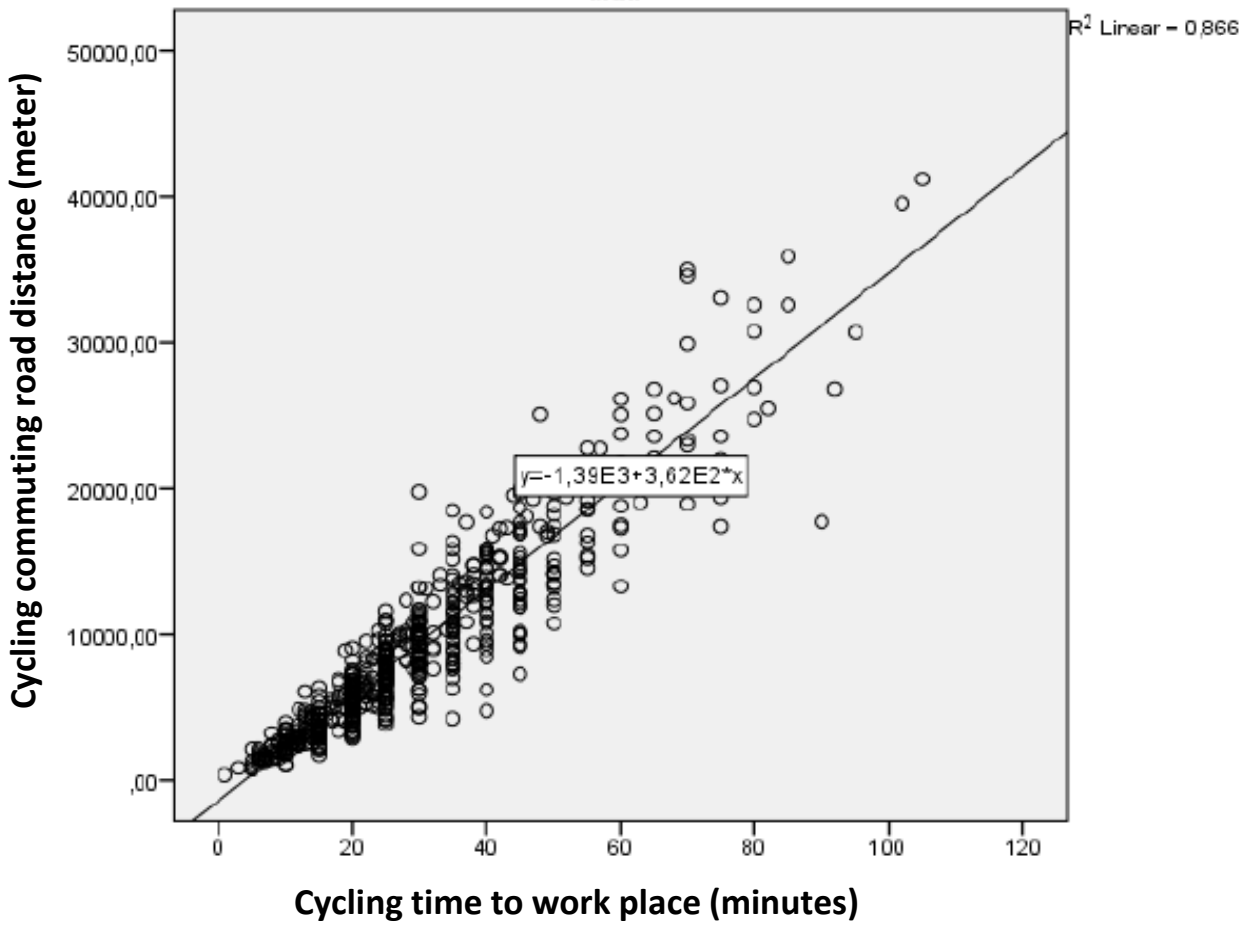
- Based on registry data transfer “actual commuting trips”
- Estimate the health effects for the individuals who change their mode of transport from car to bicycle
  - Physical activity
  - Air pollution
  - Accidents
- Estimate the health effects in the total population as a result of reduced exposure to air pollution
  - Including also the health effects among already existing bicycle commuters

For this we need

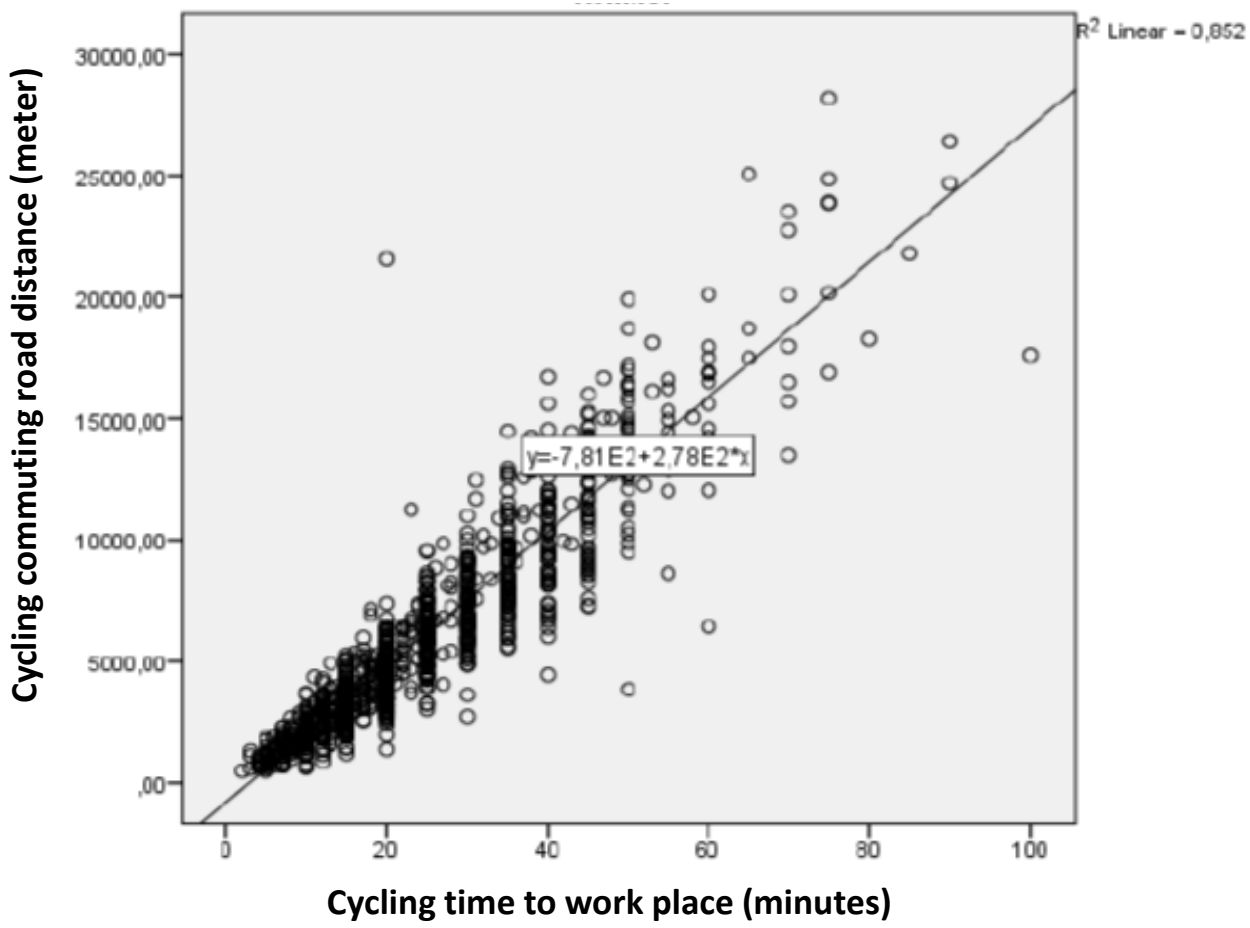
- In the working population living in Stockholm county, home and work address
- Information on mode of transport to work today
- The individual potential to bicycle the distance within a certain time
- The definition of a realistic scenario

Traveling speeds among current bicycle commuters

Men

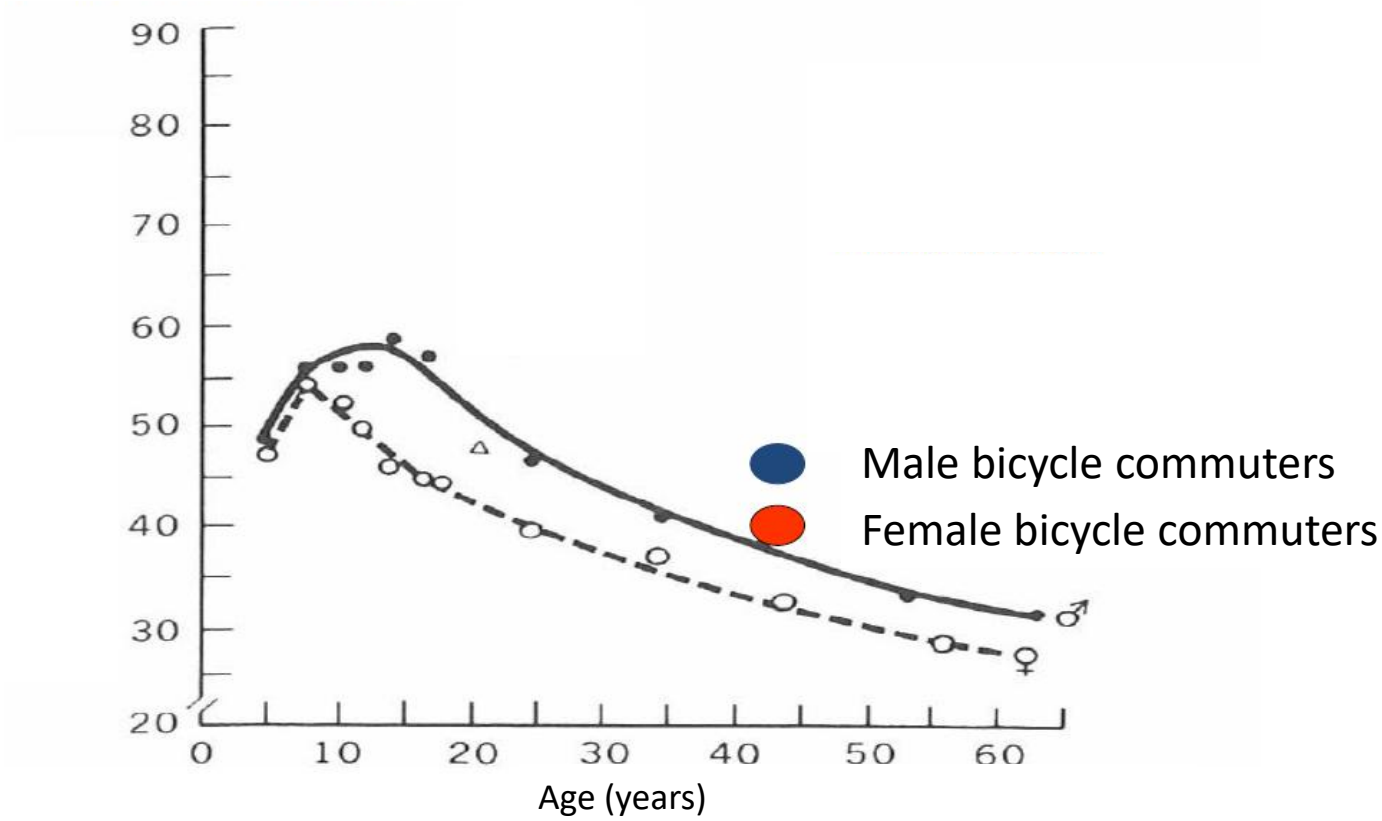


Women



Comparing maximum oxygen uptake among current commuters and the general population

Maximum oxygen uptake. ml per kilogram body weight and minute



Assumed traveling speed

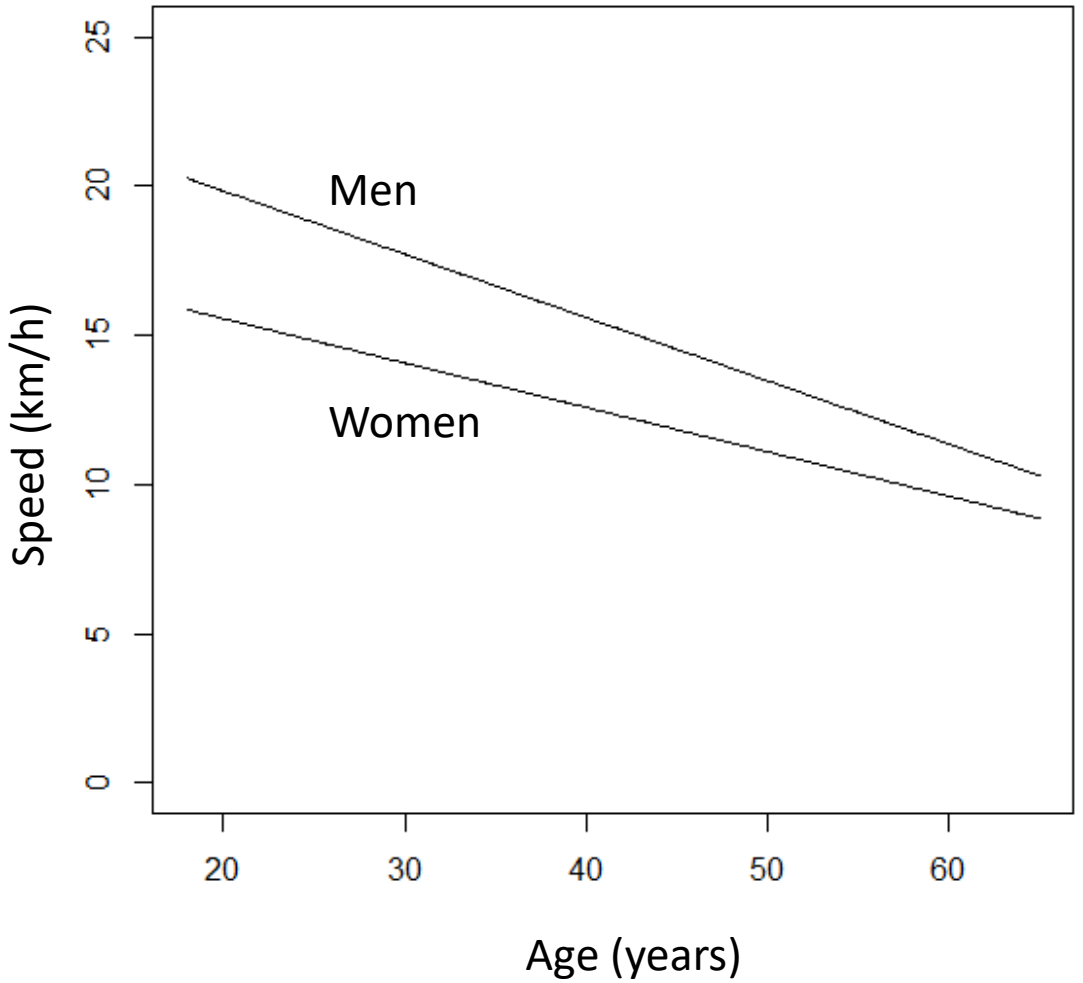
- Based on these data we estimated the bicycle speed to be:

Among men

0.719 * (34.8 + 0.31 * age (years))

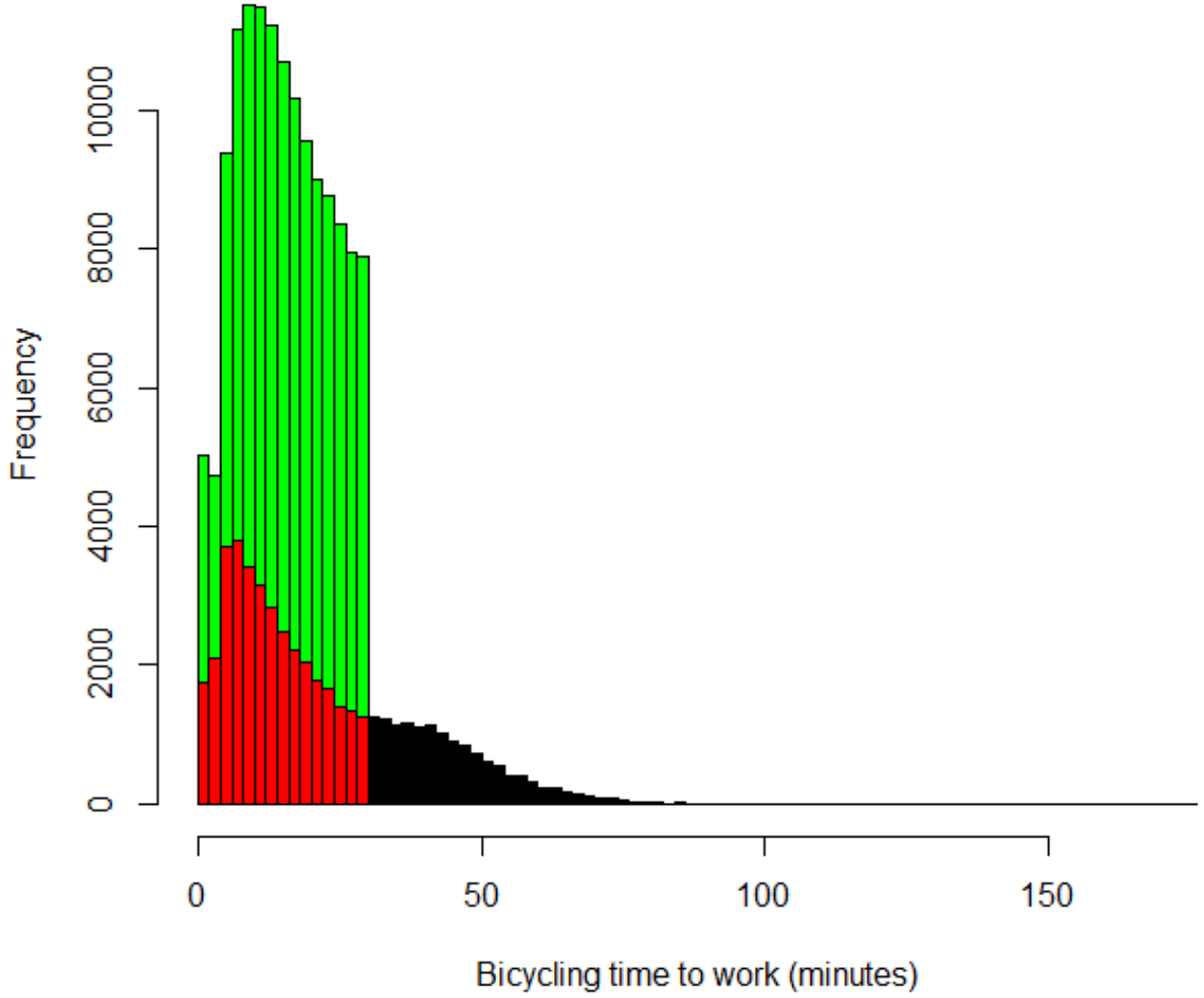
Among women

0.763 * (25.9 + 0.21 * age (years))



Scenario

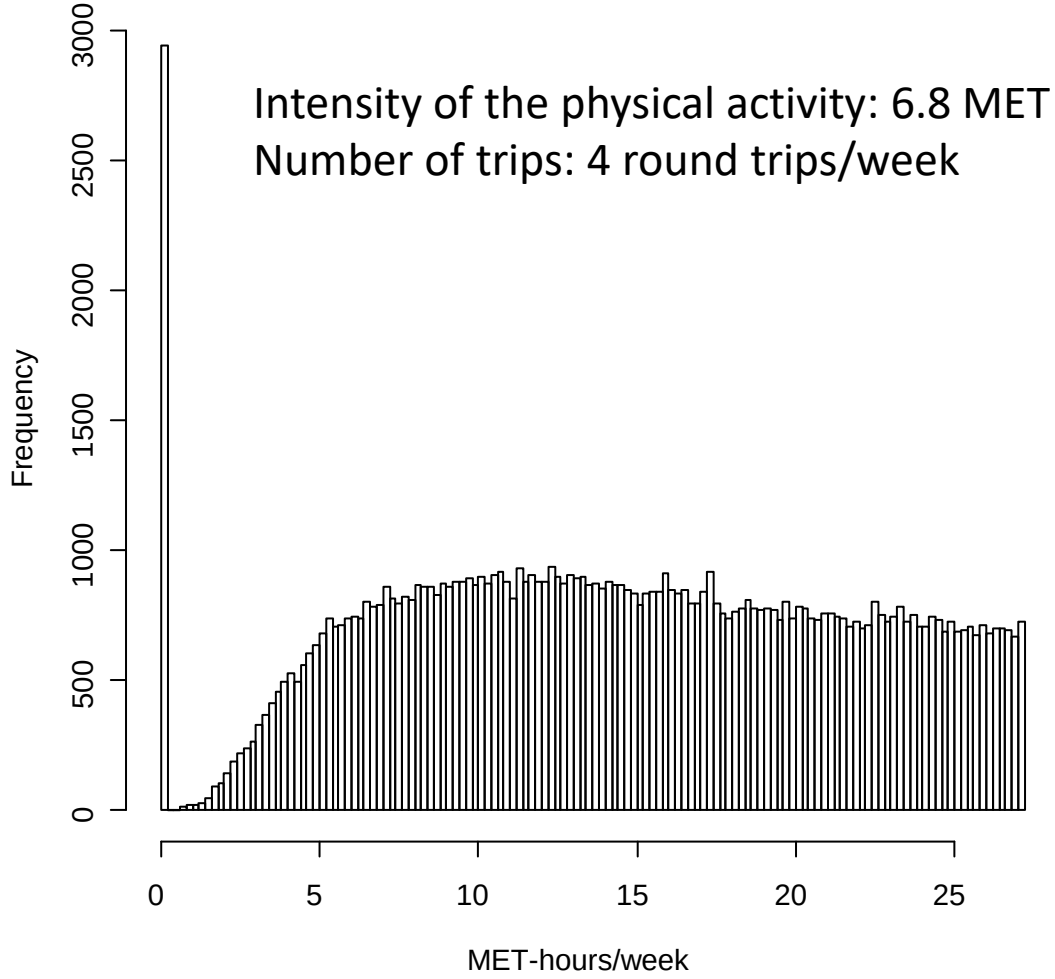
- New bicycle commuters are those that have the potential to bicycle to work within 30 minutes

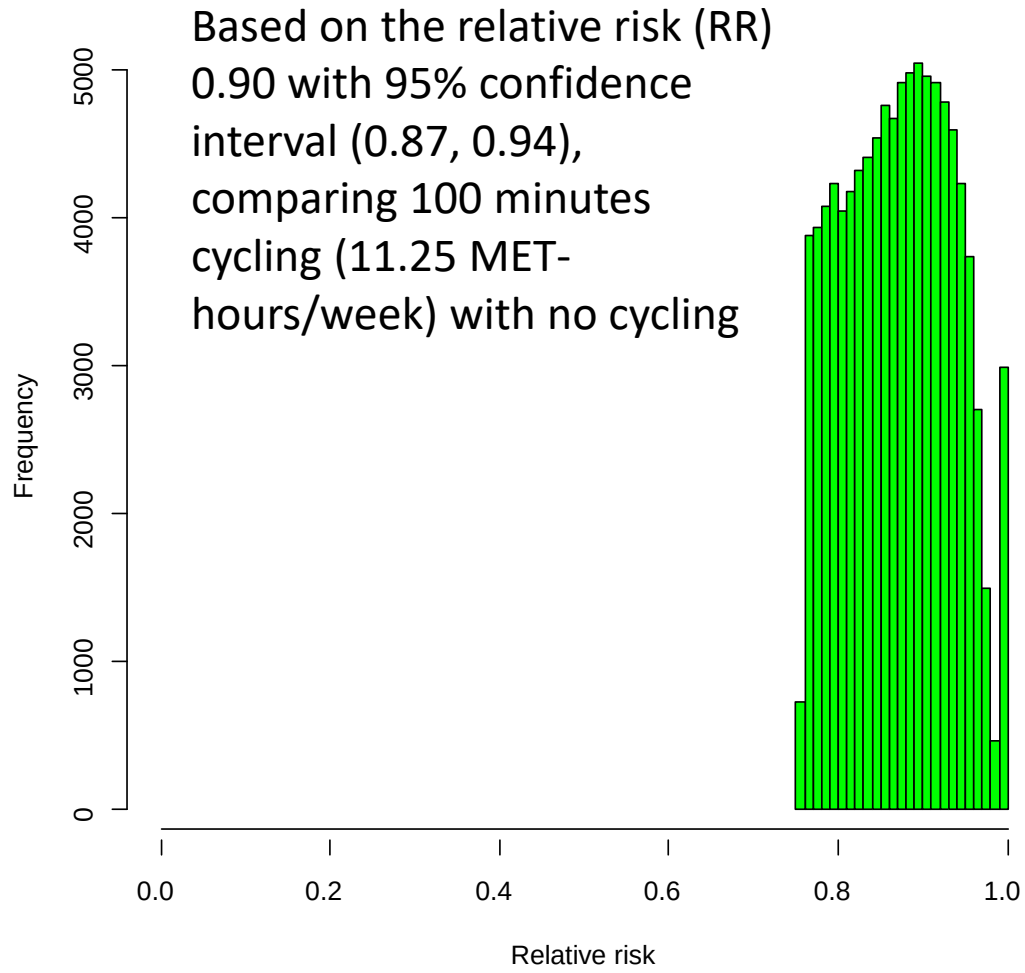


Mode of transport within current and alternative scenario

	Current situation		Alternative scenario		Difference	
Mode of transport	Number of individuals	Proportion	Number of individuals	Proportion	Number of individuals	Proportion
Bicycling	53206	6%	164693	18%	111487	12%
Walking	130441	14%	130441	14%	0	0%
Public transport	352412	38%	352412	38%	0	0%
Car (driver)	352614	38%	241127	26%	-111487	-12%
Car (passenger)	35297	4%	35297	4%	0	0%
	923970					

Size of the physical work achieved by the new bicyclists and relative risk for mortality



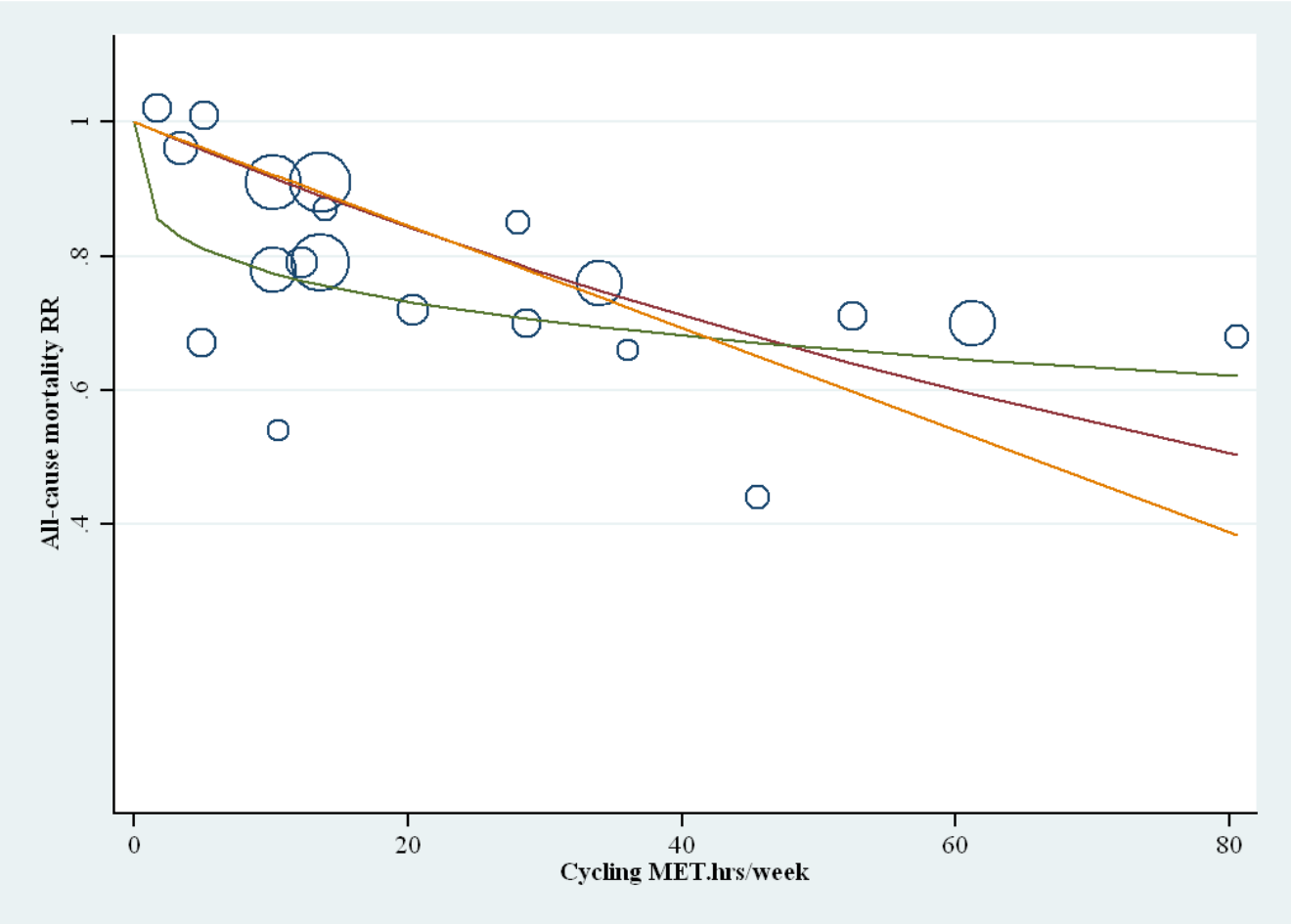


What is known from the literature about the health effects of commuting by bicycle?

Criteria:

- Study design: Prospective studies
- Age: Adults
- Estimated the relation between mortality/morbidity and both bicycling to and from work and leisure time physical activity (LTPA)

Previous meta estimate about the relation between mortality and bicycling to and from work



Relative risk (RR) was 0.90 with 95% confidence interval (0.87, 0.94), comparing 11.25 MET-hours/week with no cycle commuting

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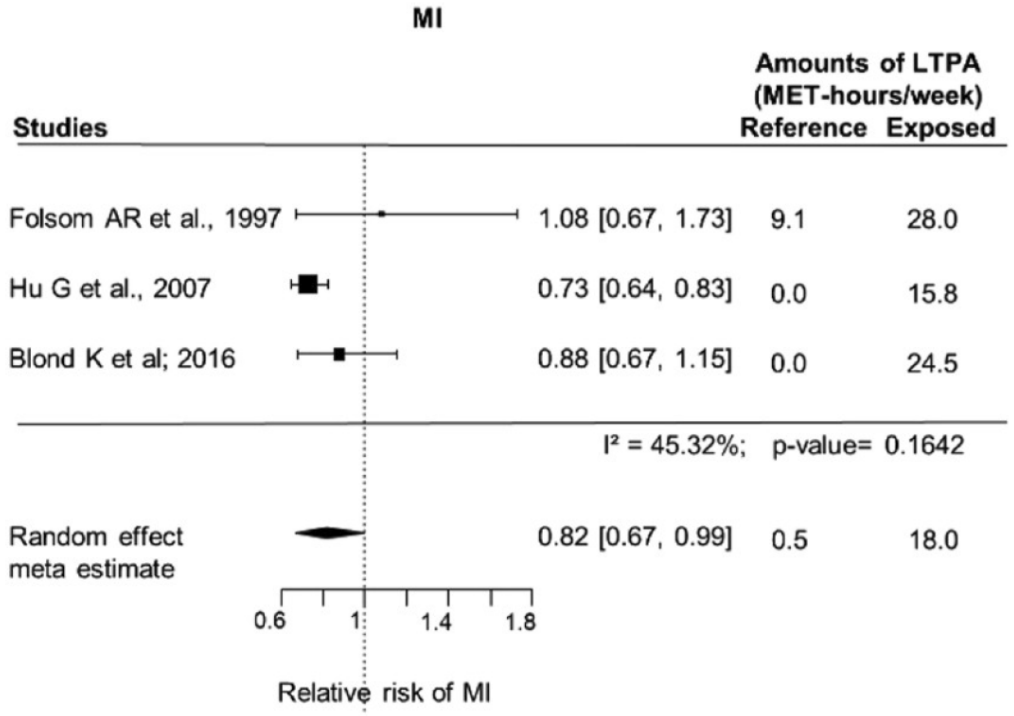
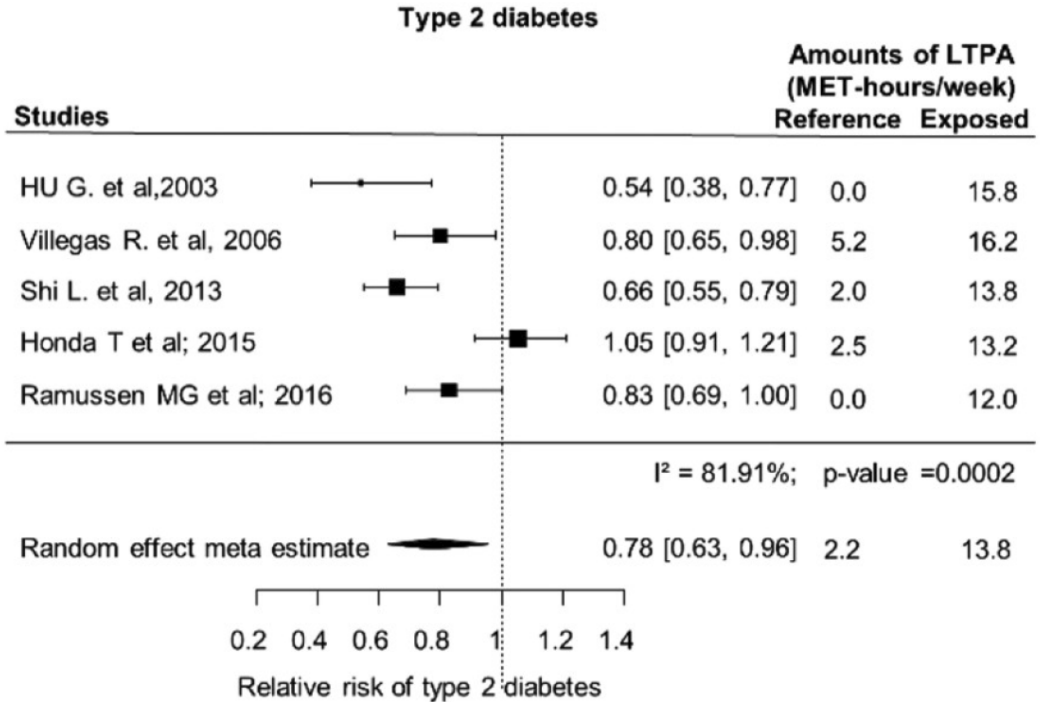
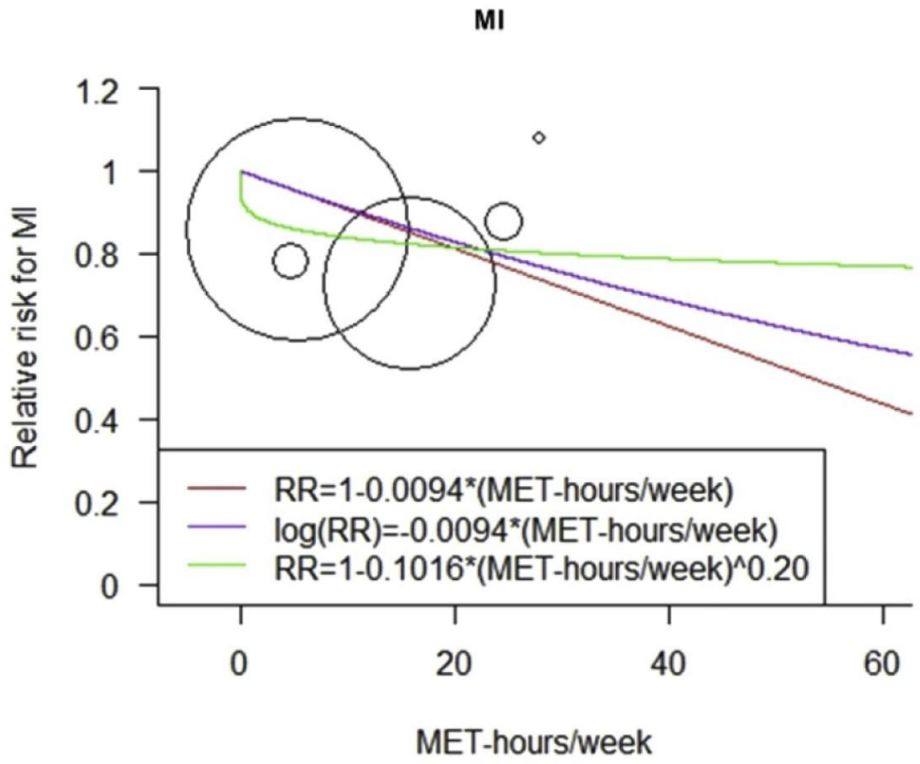
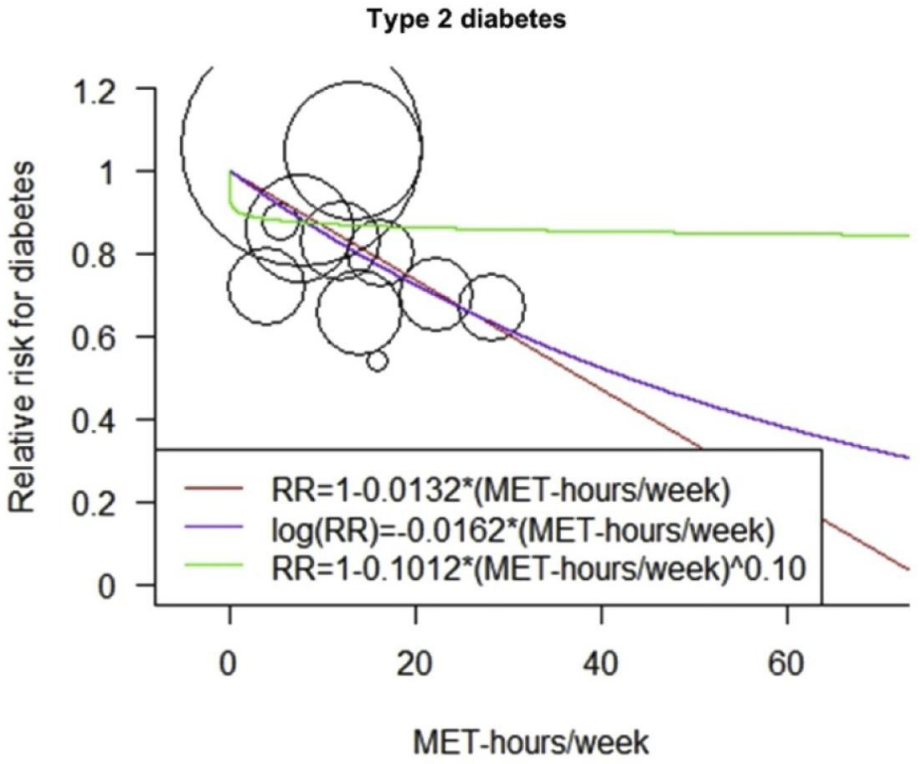
Commuting physical activity and morbidity



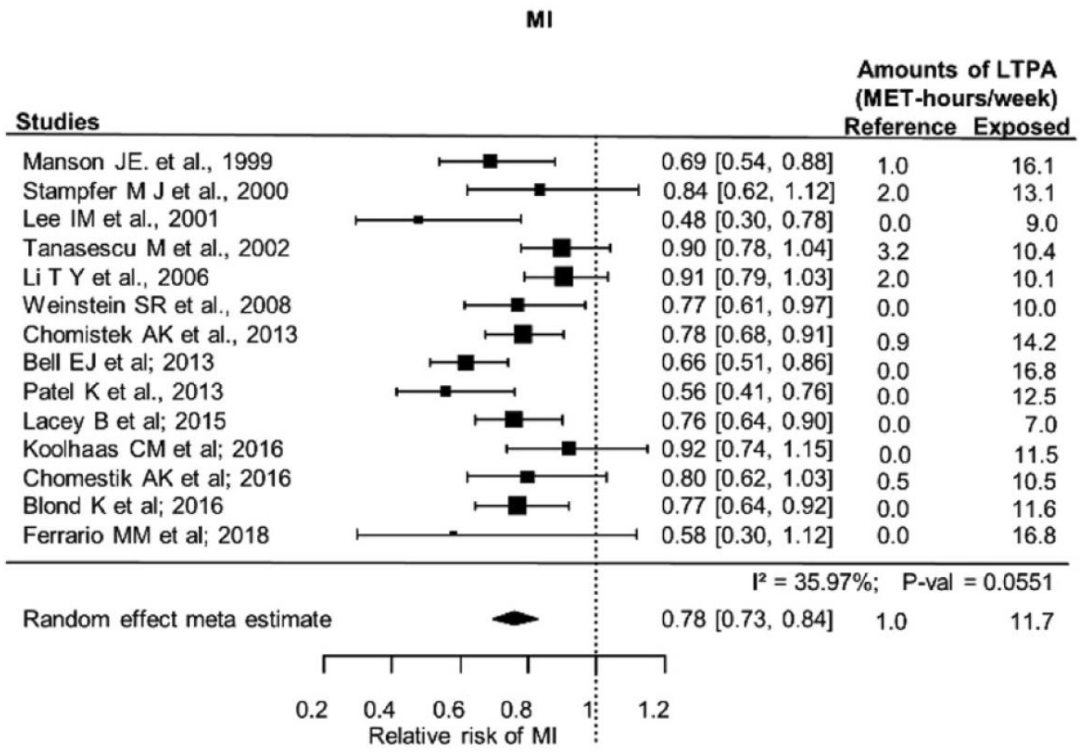


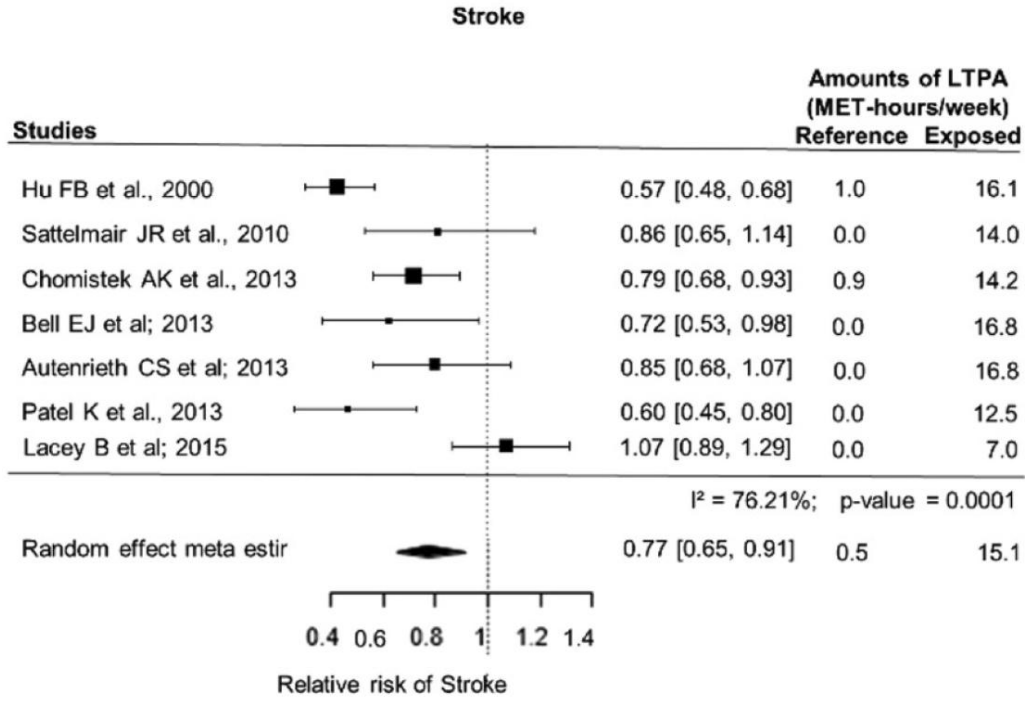
Dose-reponse between commuting physical activity and morbidity



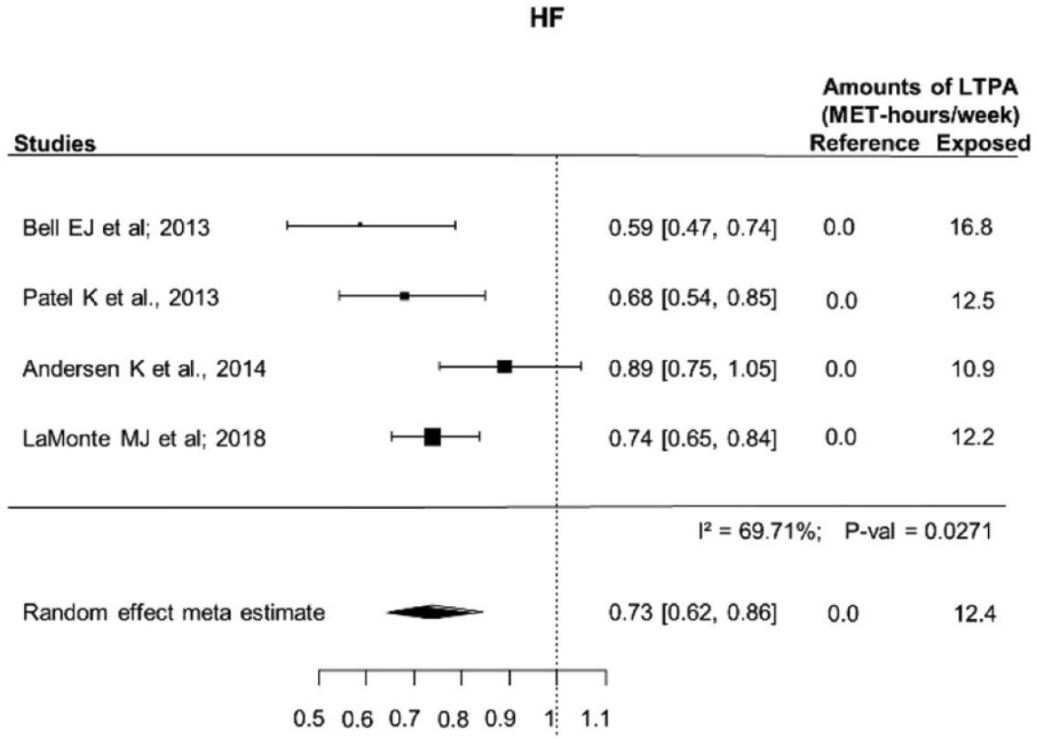


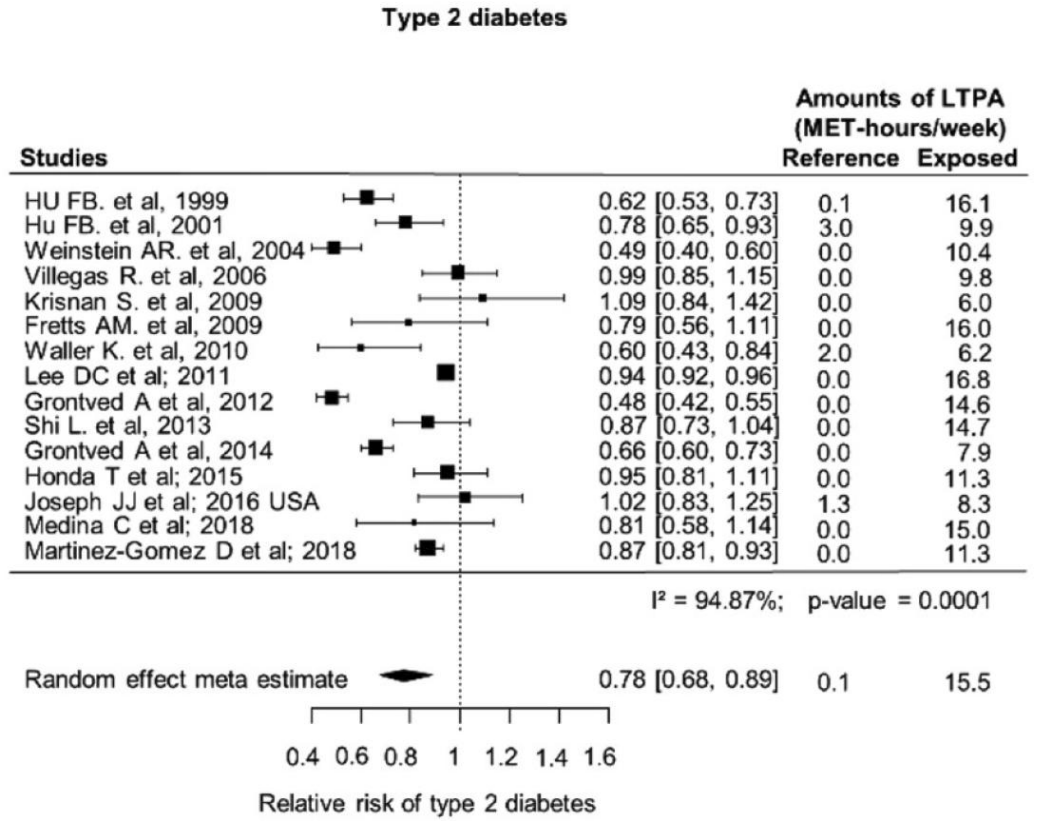
Leisure time physical activity and risk of cardiovascular disease



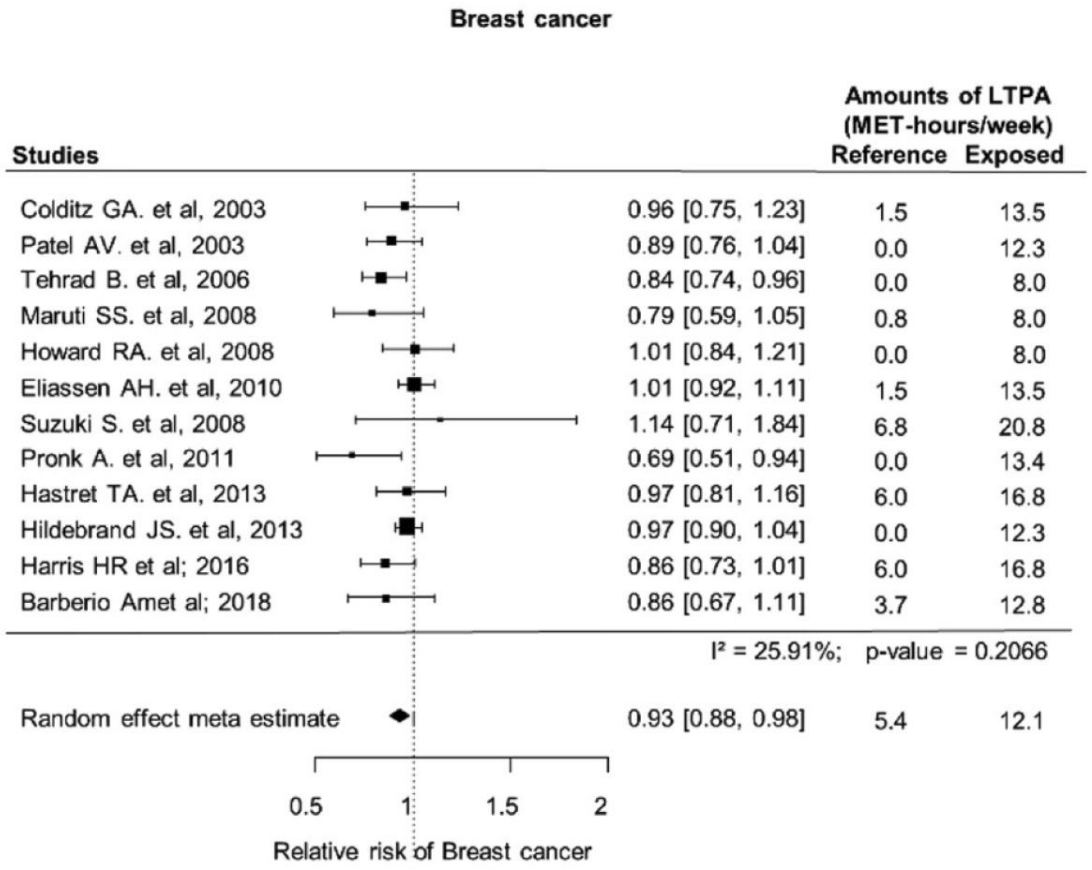


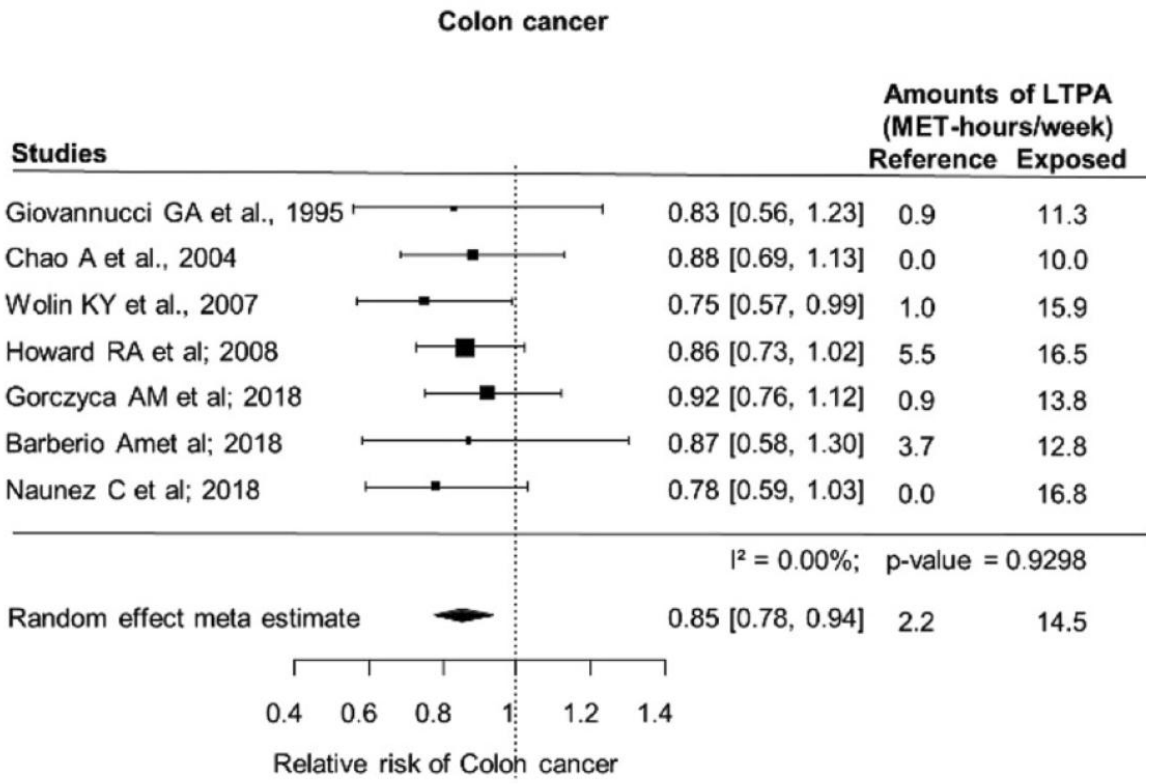
Leisure time physical activity and risk of cardiovascular disease



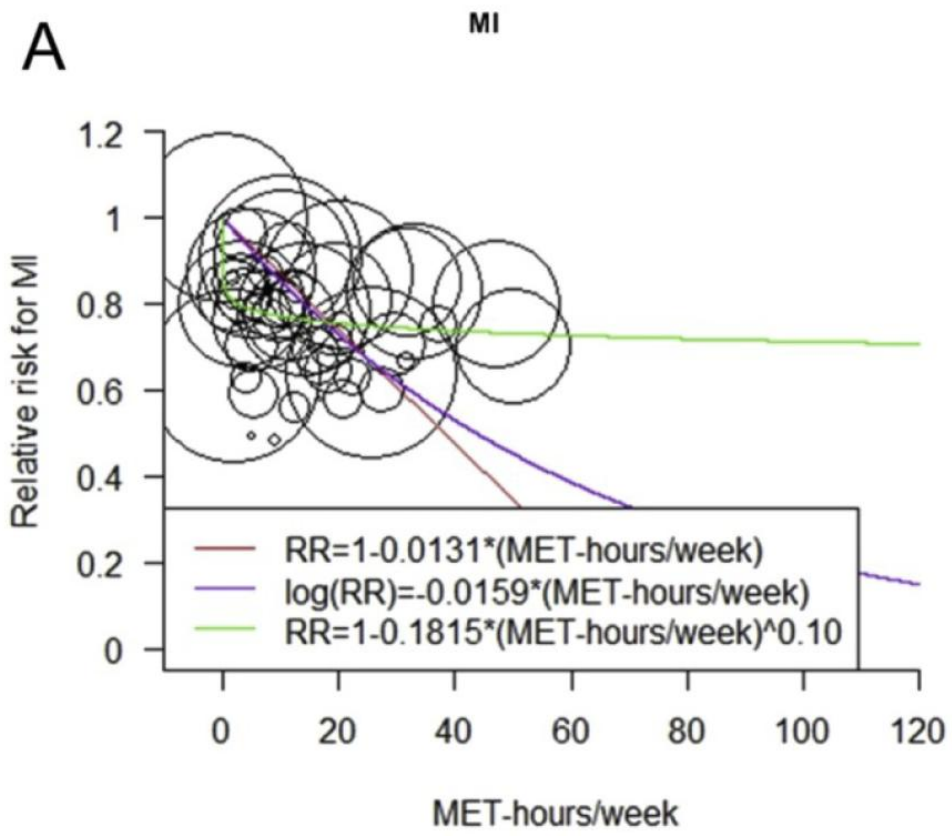


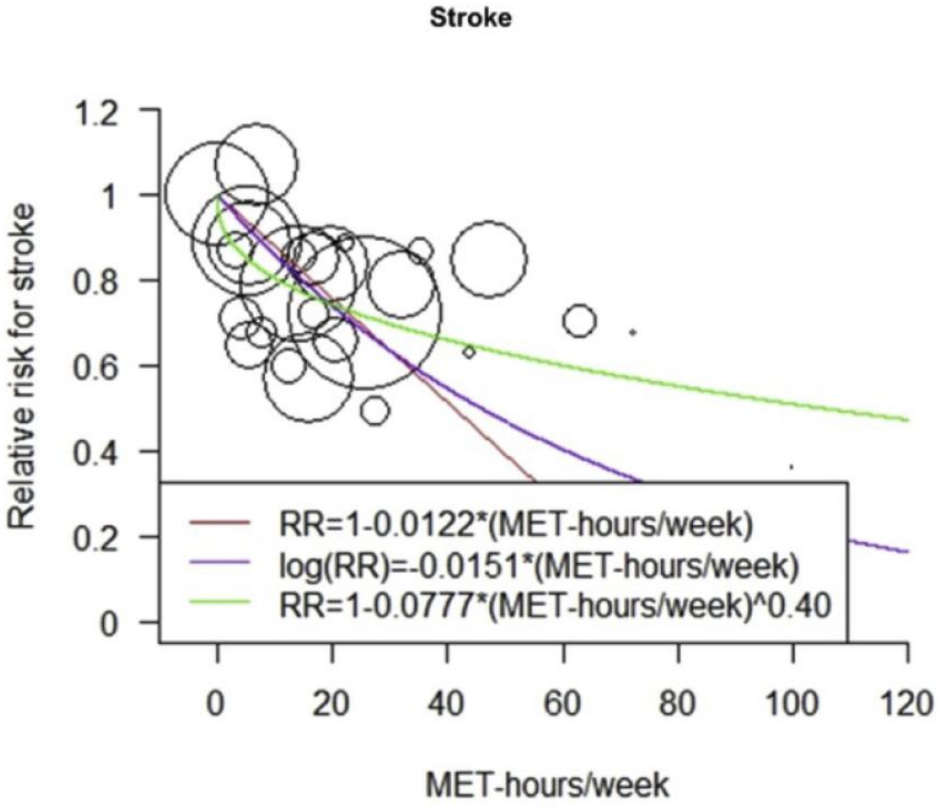
Leisure time physical activity and cancer risk



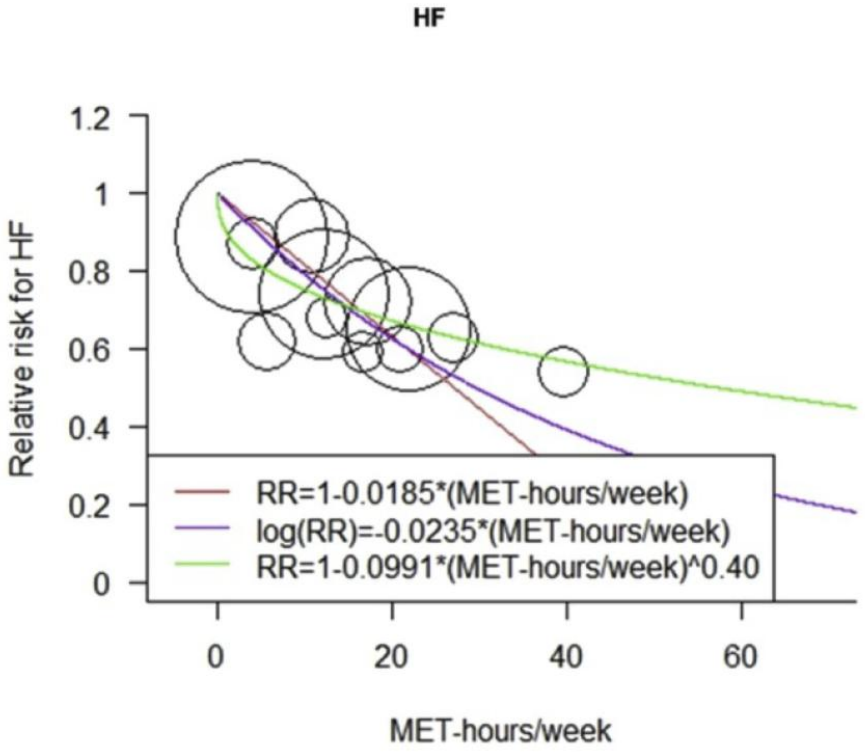


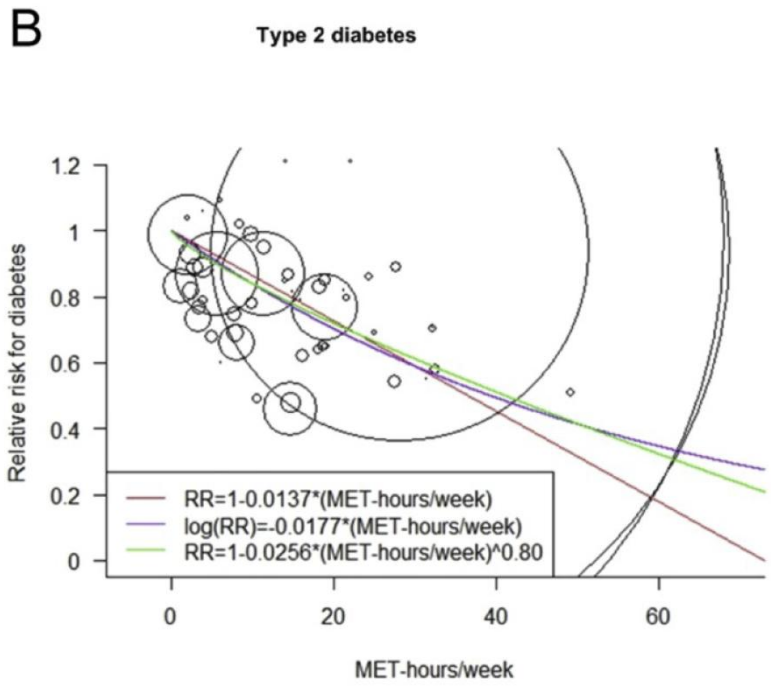
Dose-reponse between LTPA and morbidity





Dose-reponse between LTPA and morbidity





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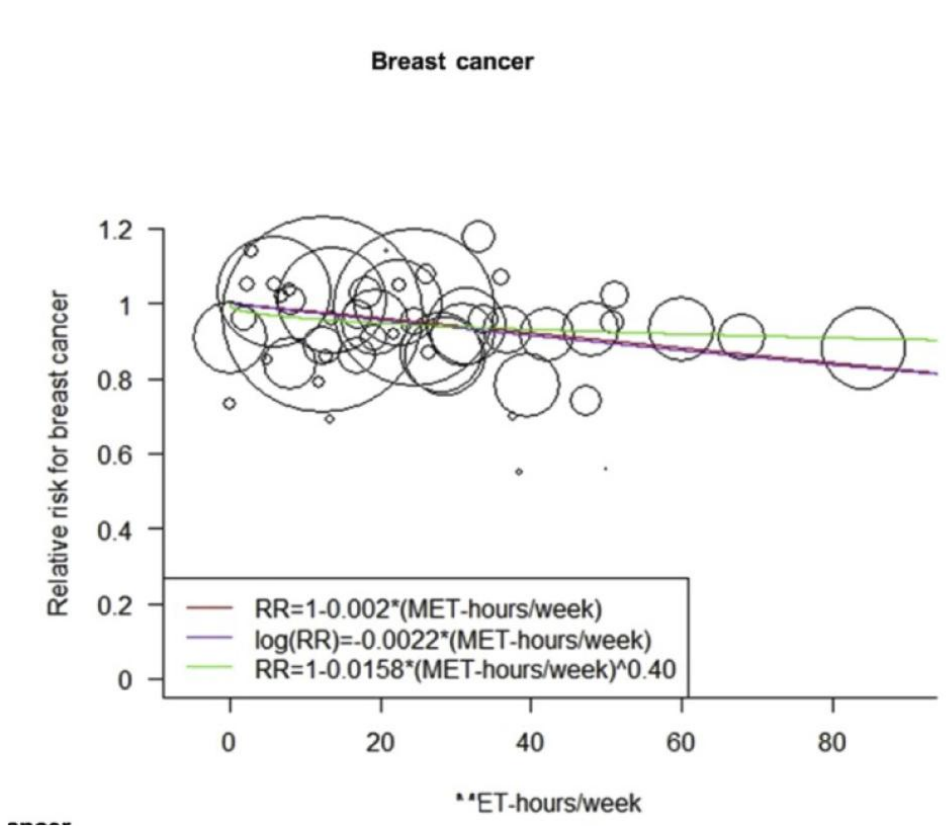
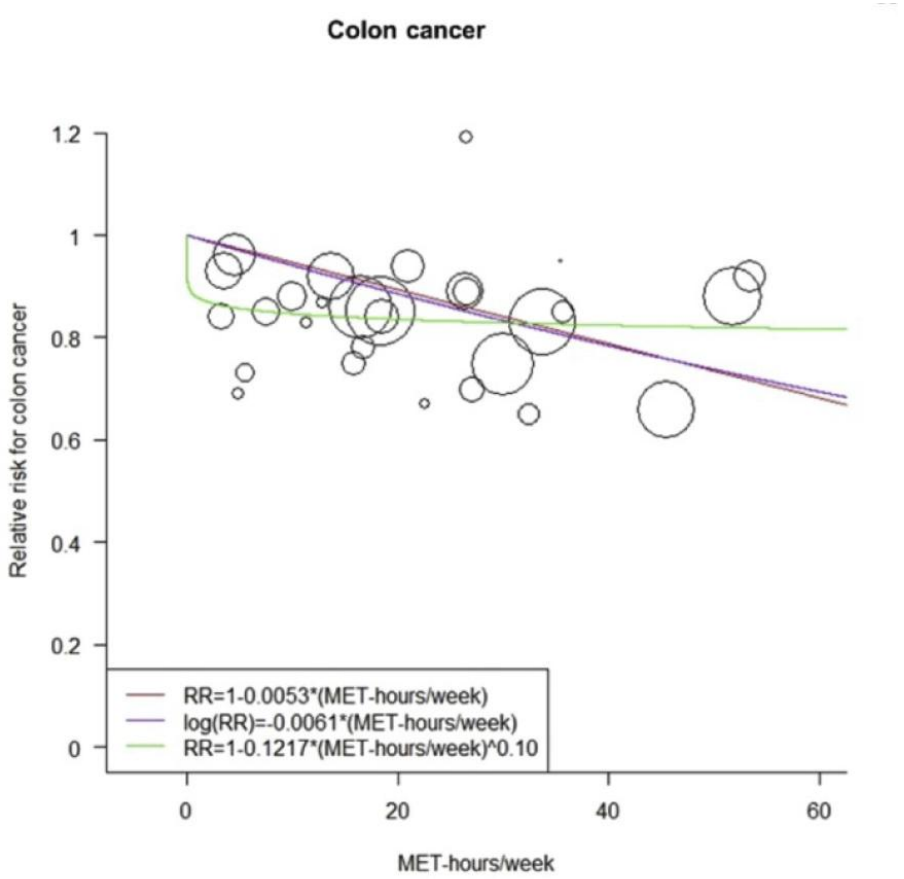


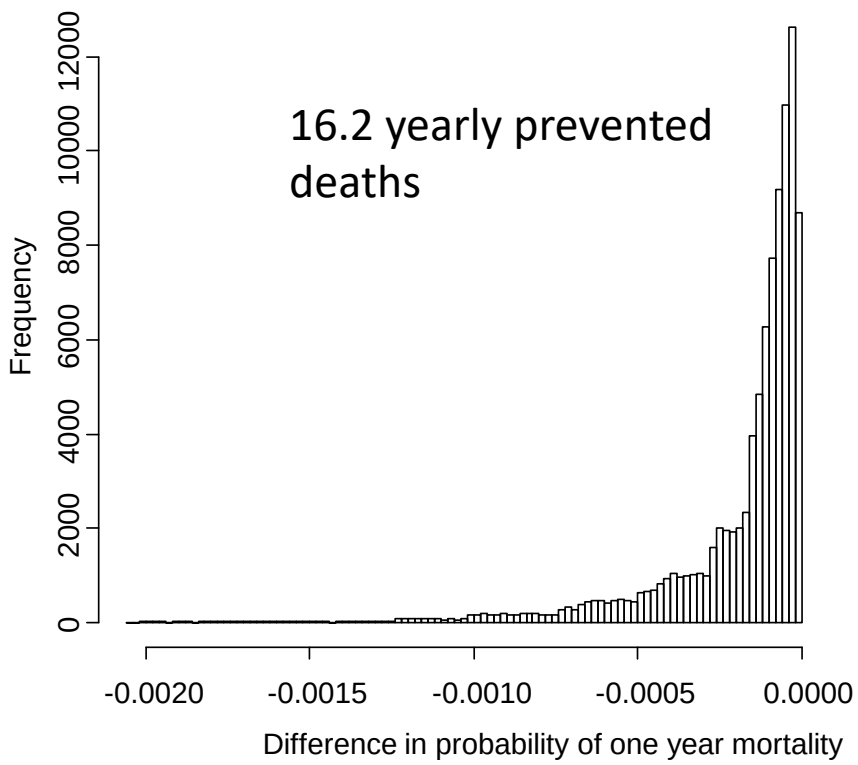


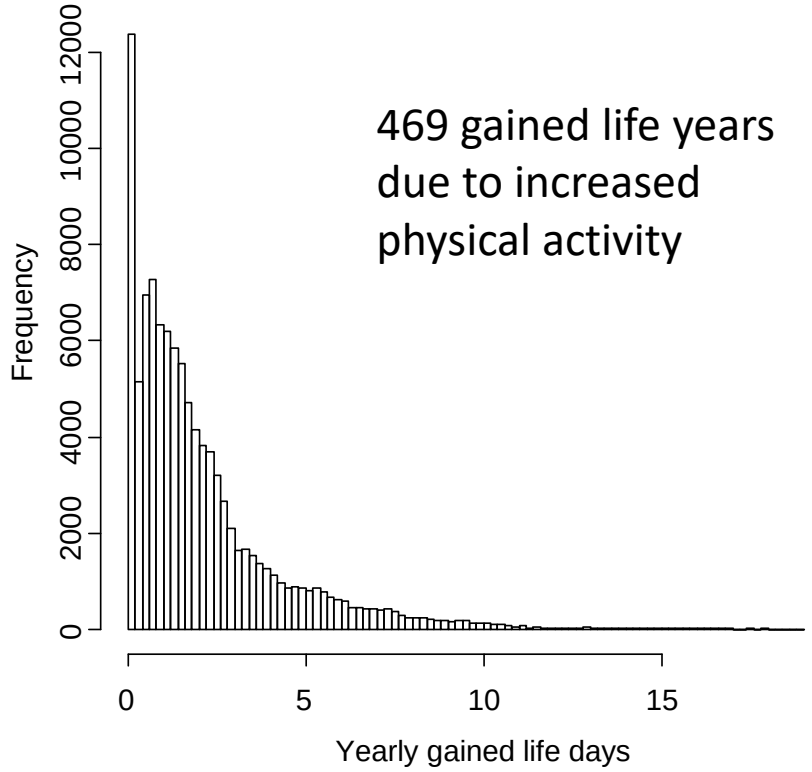
Remaining effects of previous physical activity

Relative risk of mortality (95% confidence interval)

		Wannamethee et al.	Paffenbarger et al.	Petersen et al.		Schnohr et al.		Byberg et al.	Bijnen et al.	LJssner et al.
Baseline	Follow-up			Men	Women	Men	Women			
Not active	Not active	1	1	1.70 (1.46-2.00)	1.58 (1.35-1.87)	1	1	1.33 (1.12-1.56)	2.01 (1.19-3.39)	1
Not active	Active	0.55 (0.36-0.84)	0.85 (0.65-1.13)	1.24 (1.02-1.50)	1.40 (1.13-1.75)	0.64 (0.47-0.87)	0.72 (0.50-1.05)	1.21 (0.99-1.48	1.36 (0.78-2.36)	1.11 (0.67-1.86)
Active	Not active	0.75 (0.50-1.14)	1.1 (0.78-1.50)	1.42 (1.01-1.80)	1.31 (1.01-1.68)	1.11 (0.76. 1.62)	0.72 (0.48-1.07)	1.35 (1.12-1.61)	1.72 (1.04-2.85)	2.07 (1.39-3.09
Active	Active	0.58 (0.41-0.82)	0.82 (0.63-1.08)	1	1	0.61 (0.48-0.76)	0.66 (0.51-0.85)	1	1	1

What does this mean for yearly prevented deaths?





Health gain from increased physical activity

		Current scenario	30 minutes scenario	Difference
YLD (cases)				
	Breast cancer	186 (73)	170 (67)	-15.6 (-6.1)
	MI	24 (77)	19 (61)	-4.8 (-15.6)
	Stroke	197 (69)	140 (49)	-57.4 (-20.0)
	Diabetes, type 2	397 (342)	295 (255)	-102.1 (-87.3)
	Heart failure	120 (37)	83 (26)	-36.8 (-11.1)
	Colon cancer	60 (16)	50 (13)	-10.5 (-2.8)
YLL (cases)		4091 (143)	3622 (127)	-469 (-16.2)
DALYs		5074	4379	-695

Where does the bicycle traffic increase?

Götgatan +50 %
Liljeholmsbron +40 %
Skeppsbron +60%
Västerbron +65 %
Solnavägen +80 %

Approximate increase in number of bicyclists

- 1 - 200
- 201 - 500
- 501 - 800
- 801 - 1500
- 1501 - 2600

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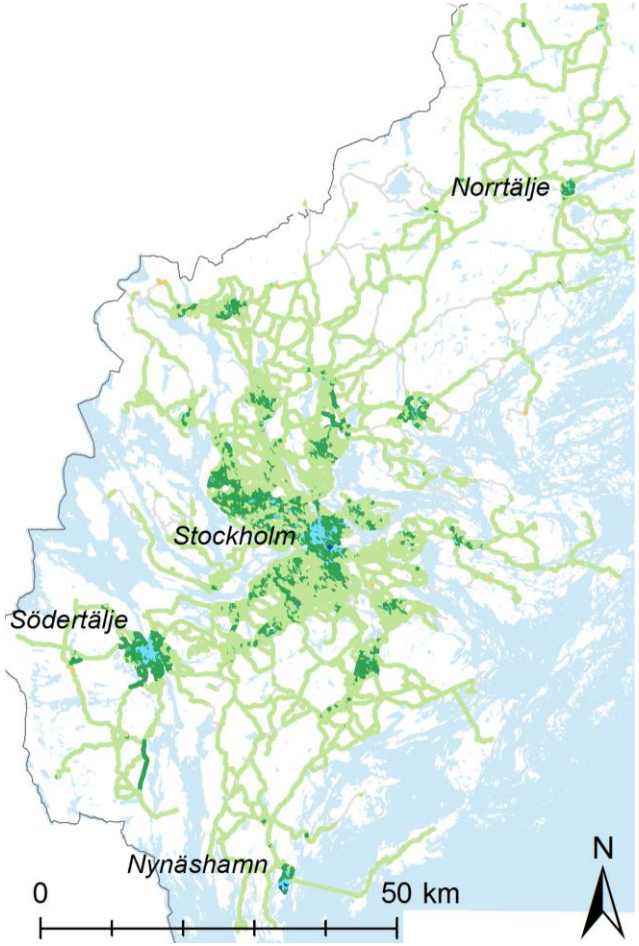
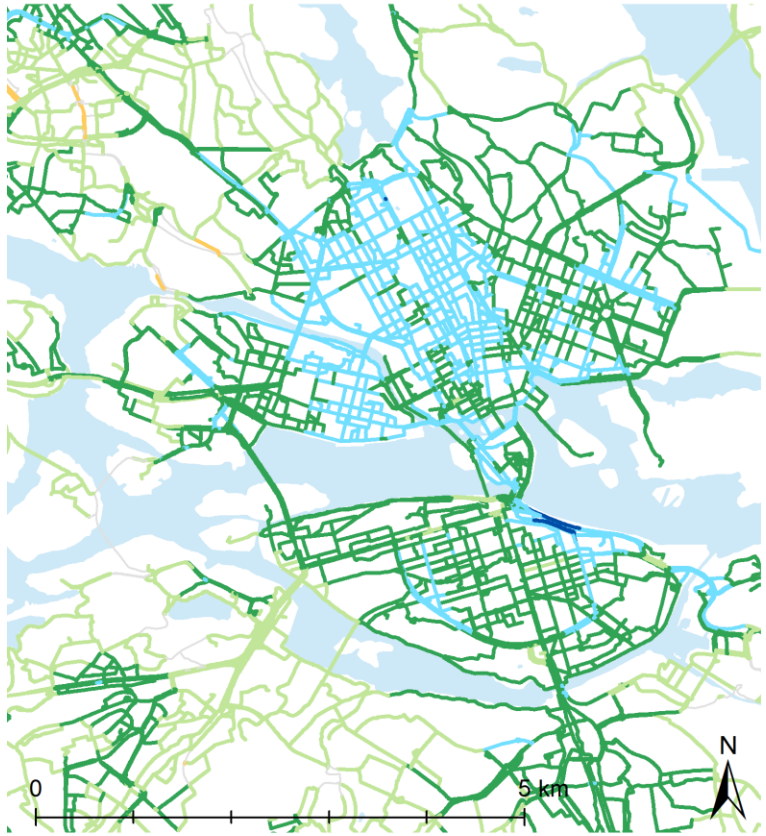
Change in air pollution along bike paths



NOx, morning rush hour during April-October

- > -20 %
- -20 - -10 %
- -10 - -5 %
- -5 - -1 %
- unchanged
- 1 - 5 %

Average for the whole county: 6 – 7 % reduction



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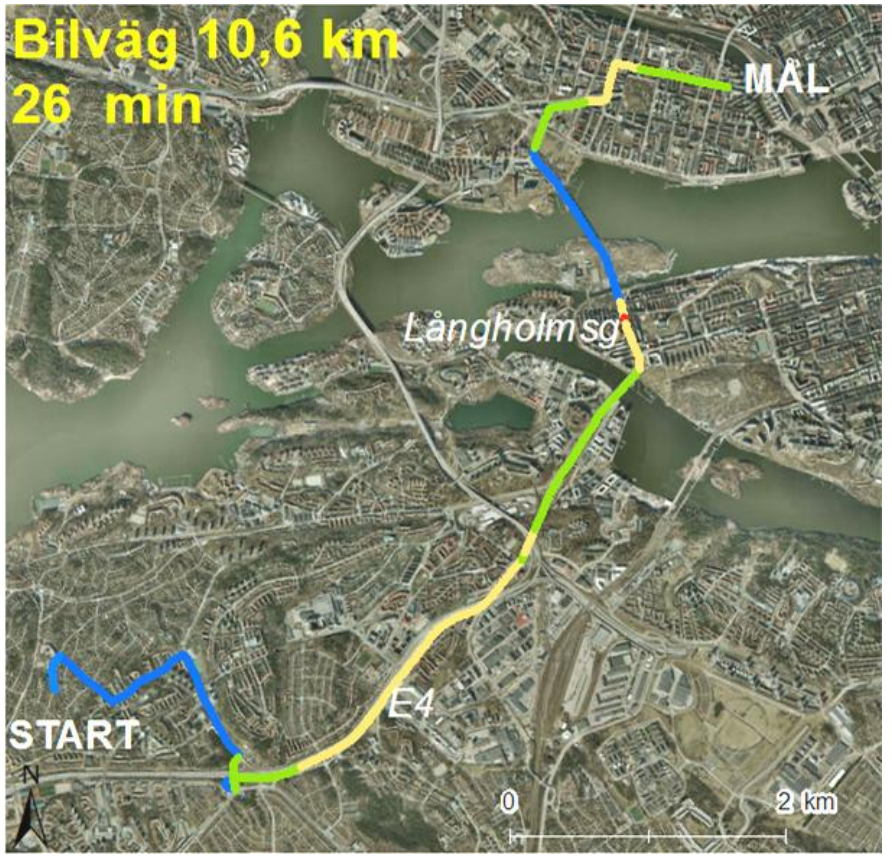
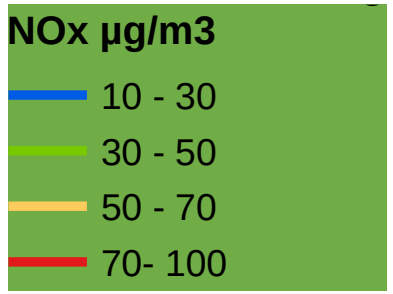
NOx concentrations while traveling by bicycle and car – an example journey





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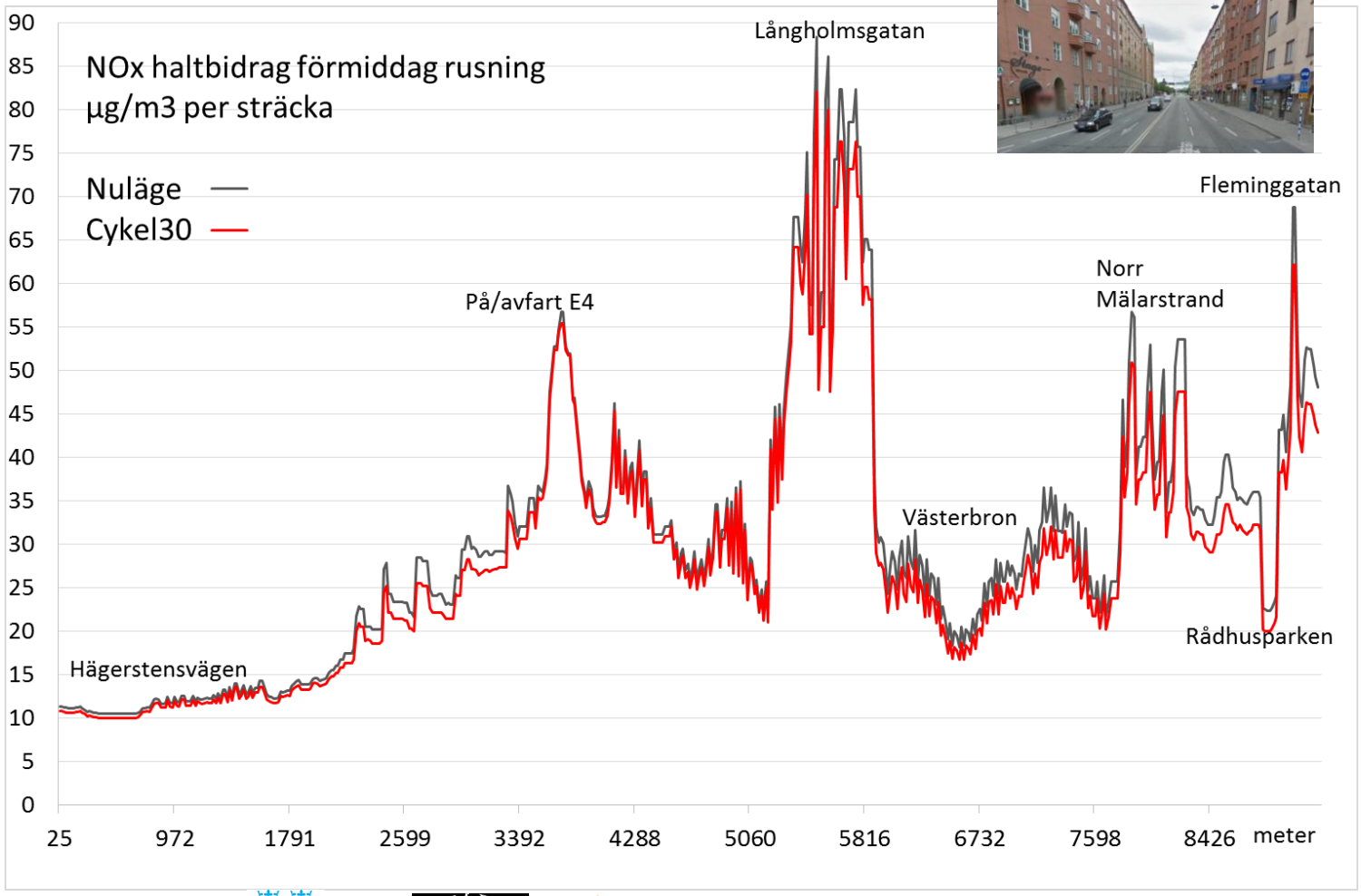
The accumulated NOx concentration for the bicyclist was 30% lower compared to traveling by car on these routes

How much is the bicyclist's NOx exposure reduced in the alternative scenario?



7% reduction for this route

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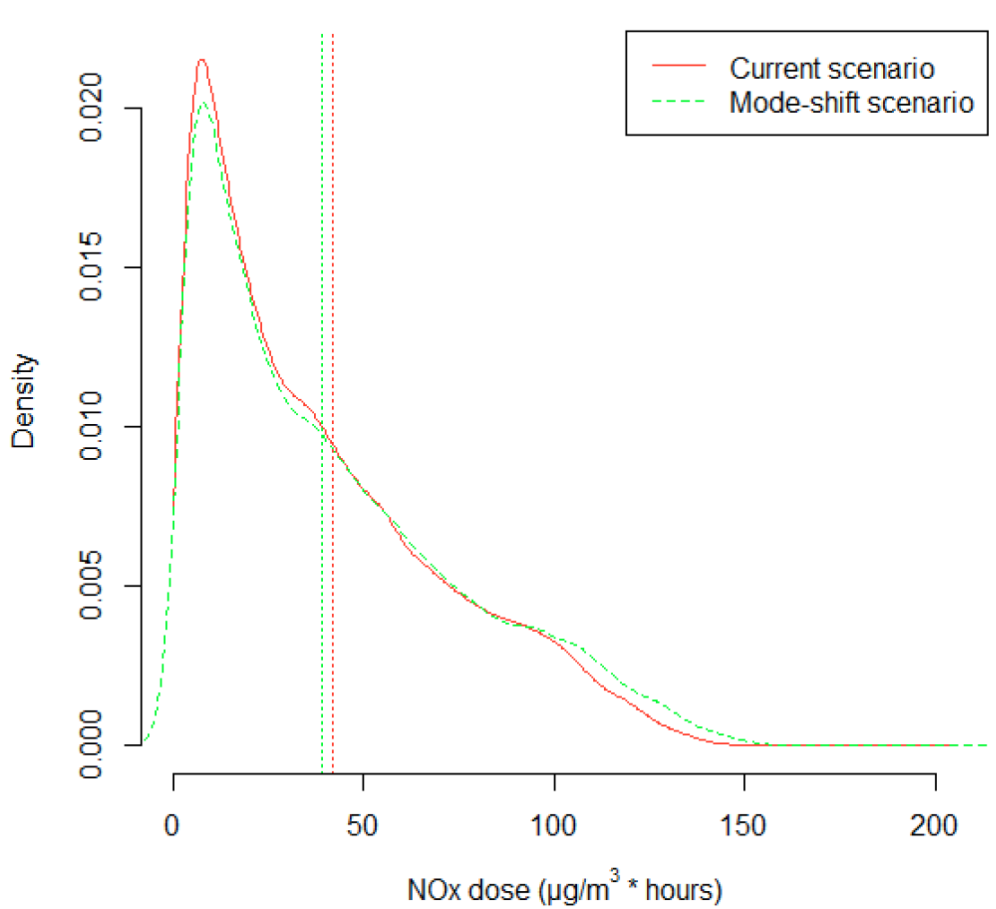
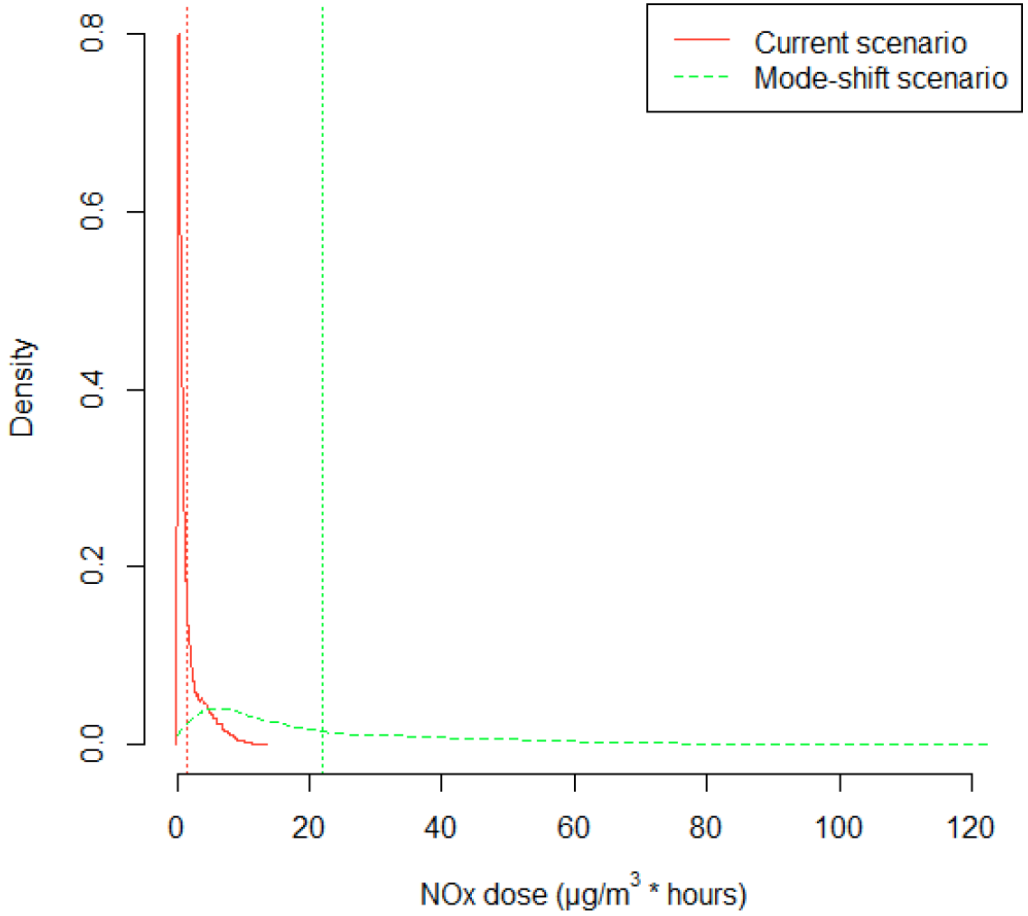
Distribution of cumulative NOx doses for a one-way trip

(**a**) among current bicyclists (**b**) among the individuals that changed their mode of transport from car to bicycle. To contrast between the two modes of transport, the difference in travel time was resolved by assuming that time not spent commuting was spent at home



(**a**)



(**b**)

Implemented relative risk estimates and disability weights

Exposure		Outcome	Disability weight	Relative risk	Increment (µg/m³)	Original study	Agegroup (years of age)
Exhaust	NOx	Mortality		1.08 (1.06-1.11)	10	Nafstad et al., 2004 [41]	All ages
	BC	Mortality		1.06 (1.05-1.07)	1	Hoek et al., 2013 [42]	>30
	PM2.5	Stroke	Long term 0.171 Short term 0.92	1.33 (1.01-1.77)	5	Meta-analysis by Staffogia et al., 2014) [44]	>30
Traffic related air pollution	PM10	Lung cancer	0.15	1.22 (1.03-1.45)	10	Meta analysis by Raaschou-Nielsen et al., 2013 [45]	>30
	PM10	Myocardial infarction	0.395	1.12 (1.01-1.25)	10	Meta analysis by Cesaroni et al., 2014 [46]	>30
	PM10	Type 2 diabetes	0.033	1.05 (1.00-1.10)	10	Weinmayer et al., 2015 [47]	>30
	PM10	Chronic brochitis	0.043	1.12 (1.04-1.19)	10	HRAPIE (WHO, 2013) [43]	>30

Health effects among new bicyclists related to increased air pollution exposure

-assuming increased intake and uptake of 330% when cycling, and 50% lower concentrations inside cars

Change in air pollution exposure among new cyclists

	Exposure	Car use	Cycling	Difference
Morbidity: YLD (number of cases)				
Stroke	PM2.5	183 (63)	187 (64)	3.20 (1.14)
Myocardial infarction	PM10	21 (69)	21 (70)	0.26 (0.88)
Diabetes (type 2)	PM10	360 (314)	362 (315)	1.92 (1.73)
Lung cancer	PM10	18 (15)	19 (16)	0.42 (0.35)
Asthma	PM10	157 (87)	158 (88)	1.60 (0.97)
Mortality: YLL (number of cases)	NOx	3672 (133)	3720 (135)	47.9 (1.69)
DALYs		4411	4466	55.3

Assuming 4 round trips, 45 weeks a year

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Health effects among current bicyclists related to increased air pollution exposure

-assuming increased intake and uptake of 330% when cycling, and 50% lower concentrations inside cars

Change in air pollution exposure among new cyclists

	Exposure	Car use	Cycling	Difference
Morbidity: YLD (number of cases)				
Stroke	PM2.5	93 (31)	93 (31)	-0.08 (-0.03)
Myocardial infarction	PM10	10 (32)	10 (32)	0.00 (-0.01)
Diabetes (type 2)	PM10	164 (142)	164 (142)	-0.02 (-0.02)
Lung cancer	PM10	9 (8)	9 (8)	-0.01 (0.00)
Asthma	PM10	79 (43)	79 (43)	-0.02 (-0.01)
Mortality: YLL (number of cases)	NOx	1735 (65)	1732 (64)	-2.63 (-0.10)
DALYs		2090	2087	-2.8

Assuming 4 round trips, 45 weeks a year

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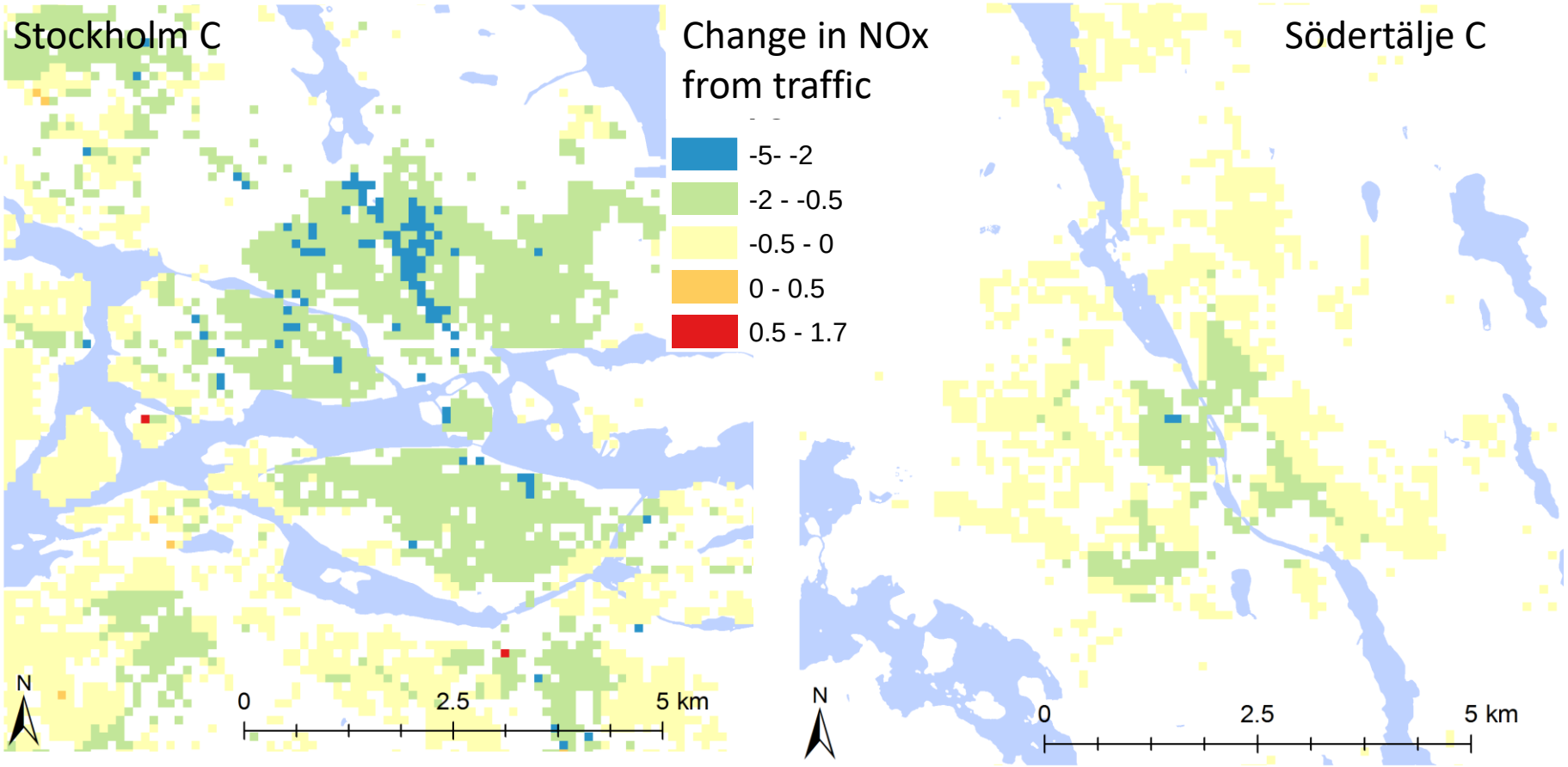
Change in total population exposure

-Traffic contribution to NOx where people live

On average a 0.3 µg/m^3 NOx reduction at the home address

We assume RR=1.08 for 10 µg/m^3 increase (Nafstad) and current mortality

Corresponds to 63 yearly prevented deaths



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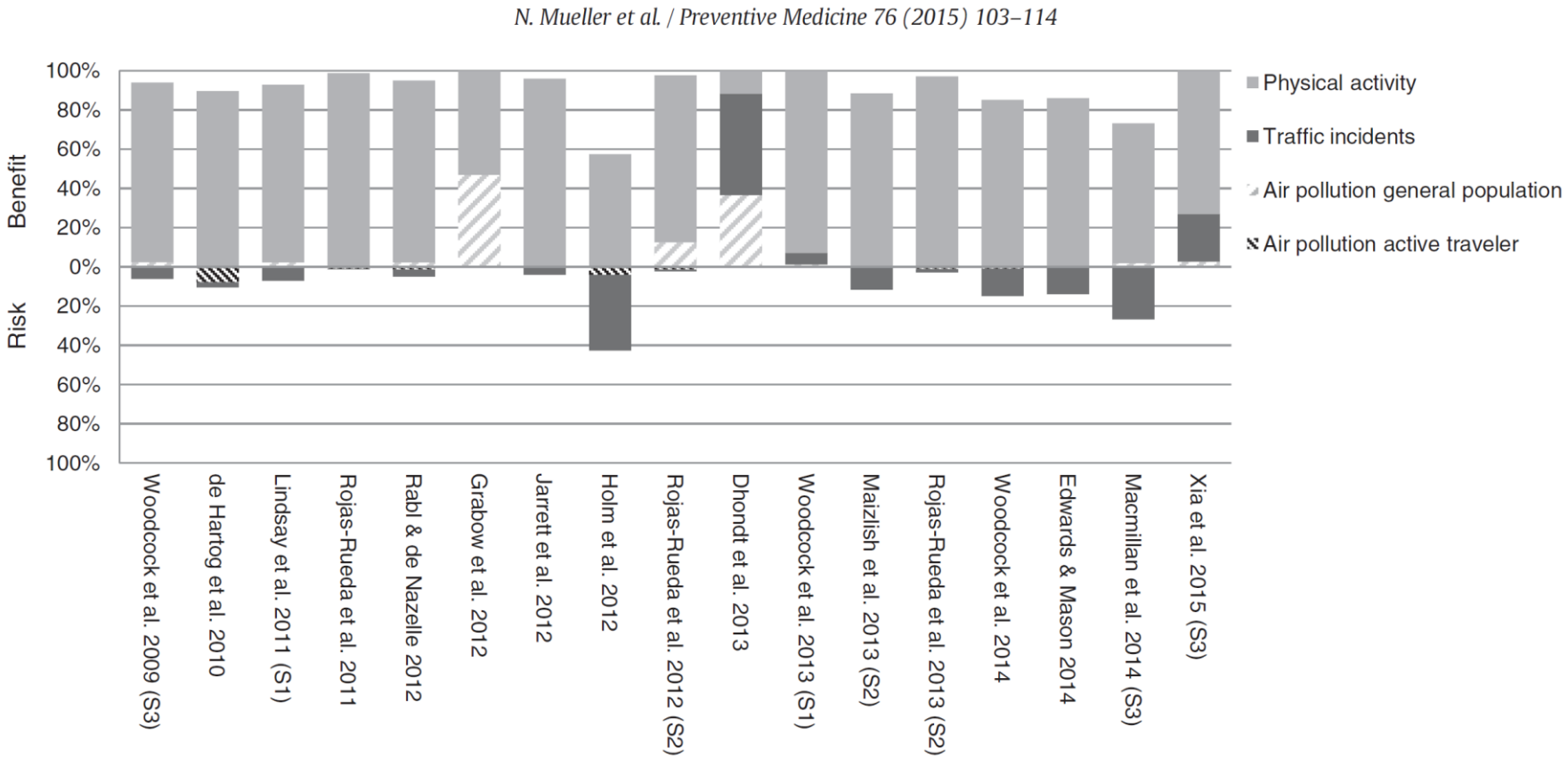
Summary and comparison

- The health effects of cycling attributed to air pollution
    - The health effects of this exposure is accounted for also in the RR estimate of physical activity from bicycle commuting
- Increased air pollution exposure among new bicyclists
    - Almost 10% reduced benefit from cycling
- Injuries
    - Increased fatalities, two additional deaths per year was calculated

Conclusions

- the largest health benefit was estimated due to the increased amount of physical activity
- considerable health gains were however also estimated in the population due to decreased air pollution exposure

Summary and comparison



- Physical activity: -608 (50%)
- Accidents: 110 (9%)
- Air pollution general population: -455 (37%)
- Air pollution new bicyclists: 48 (4%)
- Air pollution previous bicyclists: -1 (0.1%)

Reaching a total benefit of 906 DALYs

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