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Comparing individual exposure to air and noise pollution in Montreal during rush hours according to the mode of transportation used

Philippe Apparicio [a], Mathieu Carrier [a], Anne-Marie Séguin [a], Jérémy Gelb [a], Marie-Ève Mathieu [b], Simon Kingham [c]

[a] Environmental Equity Laboratory, INRS Urbanisation Culture Société, Montreal, Canada
[b] Physical Activity and Health Laboratory, Department of Kinesiology, University of Montreal, Canada
[c] GeoHealth Laboratory, Department of Geography, University of Canterbury, Christchurch, New Zealand

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LAEQ Environmental Equity Laboratory

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Background

Benefits of urban cycling

- Increasing physical activity
  - Reducing chronic diseases (diabetes, cadiovascular diseases, certain types of cancer) (Hamer et al., 2008; Hu et al., 2003; Sato et al., 2007; Gordon-Larsen et al., 2009; Woodcock et al., 2009)
- Reducing air pollutant emissions (Hatzopoulou et al., 2013; Rojas-Rueda et al., 2011)

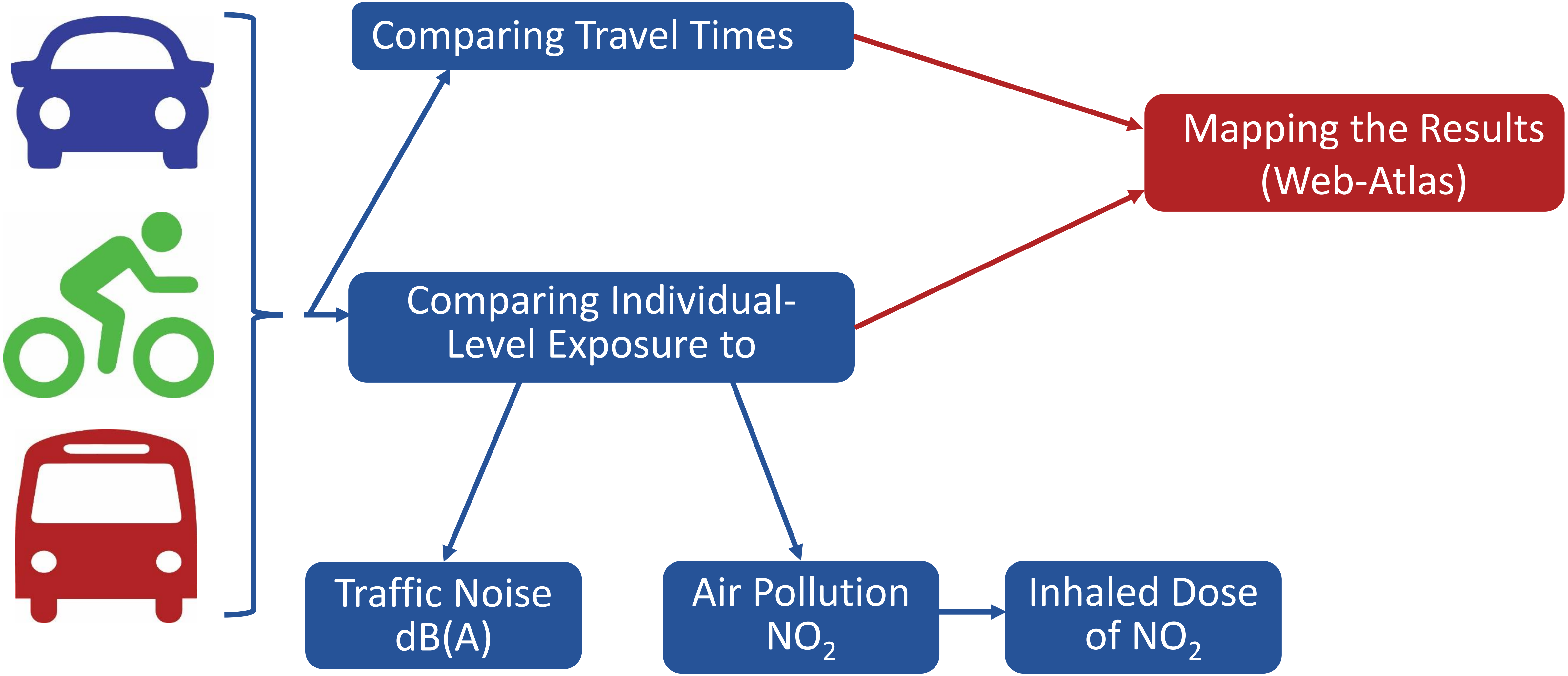
Health risks of urban cycling

- Traffic incidents (injuries and mortality) (Skic et al., 2009; Morency et al., 2011)
- Exposure to air pollution (CO, NO_2, NO_x, $PM_{2.5}$, PM_{10})
  - Development of asthma (Jerrett et al., 2008; McConnell et al., 2006)
  - Potential risk to cardiovascular health (Brugge et al., 2007; Rioux et al., 2010)
- Prolonged exposure to road traffic noise
  - Psychological stress (Passchier-Vermeer and Passchier, 2000)
  - High blood pressure (Bluhm et al., 2007)
  - Development of cardiovascular disease (Babisch, 2006)
  - Hearing loss (Seto et al., 2007)

Differences in air pollution and inhaled doses according to the modes of transportation used

- Systematic review of 39 studies (Cepeda et al., 2017)
  - Car commuters: higher exposure to air pollutants
  - Active commuters: higher inhaled doses than car commuters

Three Research Objectives



Data Collection

1 Real-time measurement of noise exposure

Brüel & Kjaer - Personal Noise Dosimeter Type 4448

- Average value of dB(A) every minute (Laeq 1 min.)
- Calibration of the device once a day using the Sound Calibrator Type 4231

2 Real-time measurement of NO_2 exposure

Aeroqual Series 500 (Portable Air Quality Sensor)

- Nitrogen dioxide (NO_2) sensor
- Temperature and humidity sensor
- Average value of NO_2 logged every minute

3 Garmin Forerunner 920 XT

- Multisport GPS Watch
- Heart rate monitor

4 Garmin VIRB XE

- Action camera
- GPS

Garmin Forerunner 920 XT
Garmin VIRB XE

Data Collection

Collection period

2016-06-16 to 2016-06-30 (dry weekdays)

Participants

8 master's students and 1 urban studies professor

- **3 teams of 3 people each**
  - One person by **car**
  - One person by **bicycle**
  - One person by **public transit**

Trips during rush hours (N = 99)

8 am: from an outlying Montreal neighbourhood to the downtown area

5 pm: in the opposite direction

Trip duration (min.)

	Bicycle	Car	Public transit
Total =	1,239 20:39:40	1,280 21:20:25	1,375 22:55:37

Trip length (km / miles)

	Bicycle	Car	Public transit
N =	33	33	33
Min. =	5.8 / 3.1	6.0 / 3.7	6.0 / 3.1
Max. =	20.0 / 12.4	20.8 / 12.4	20.0 / 12.4
Mean =	10.2 / 6.2	11.3 / 6.8	10.4 / 6.2
Total =	344 / 213	337 / 209	364 / 226

Temperature (Celsius / Fahrenheit)

Min. = 10 / 50
Max. = 39 / 102
Mean = 28 / 82

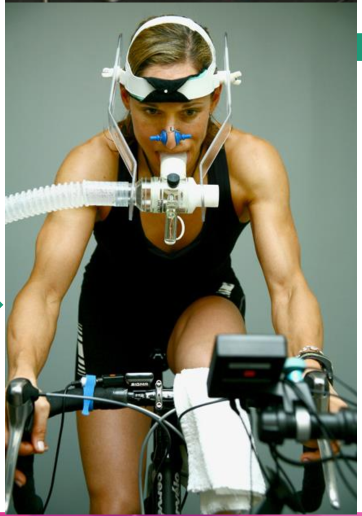
Methodology: Estimating Ventilation and Inhaled Dose of NO_2

1. Test for each participant
Marie-Eve Mathieu
Department of Kinesiology
Physical Activity and Health Lab.
University of Montreal

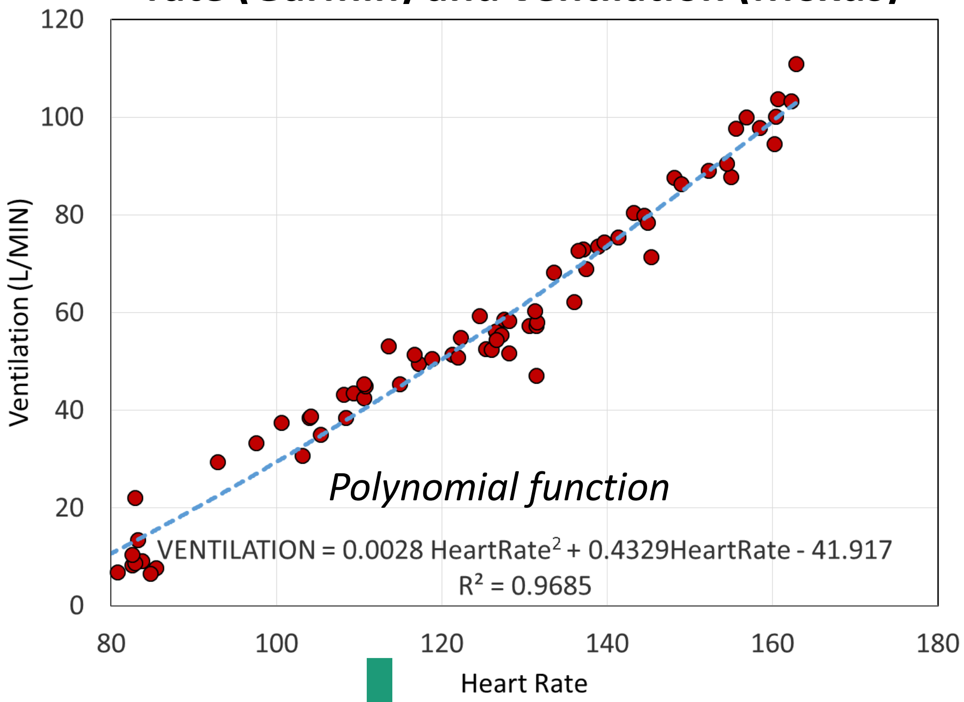
5 min. 5 min.

5 min. 5 min.

Progressive and maximal test



2. Individualized equation between heart rate (Garmin) and ventilation (Moxus)

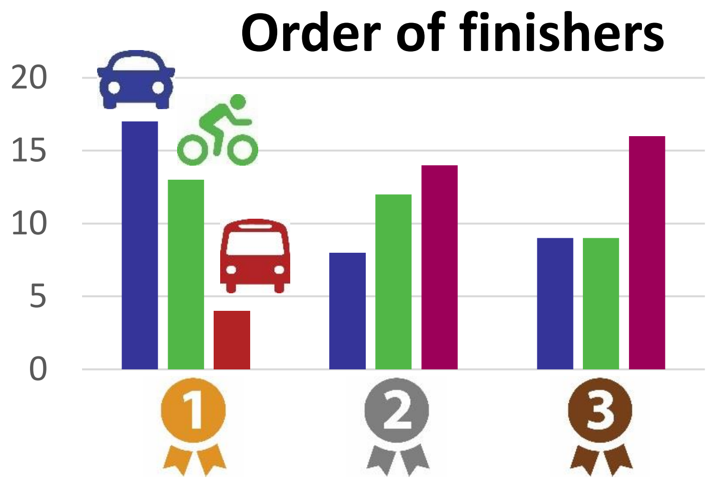


3. Estimation of the ventilation per minute based on heart rate values measured by the multisport Garmin watch during the trip

4. Estimation of the dose of NO_2 inhaled per minute during the trip

µg NO_2 = (V / 1000) * P with
V = Ventilation (liters per min.); P = NO_2 value

Results: Comparing Travel Times



Travel times* (min.)

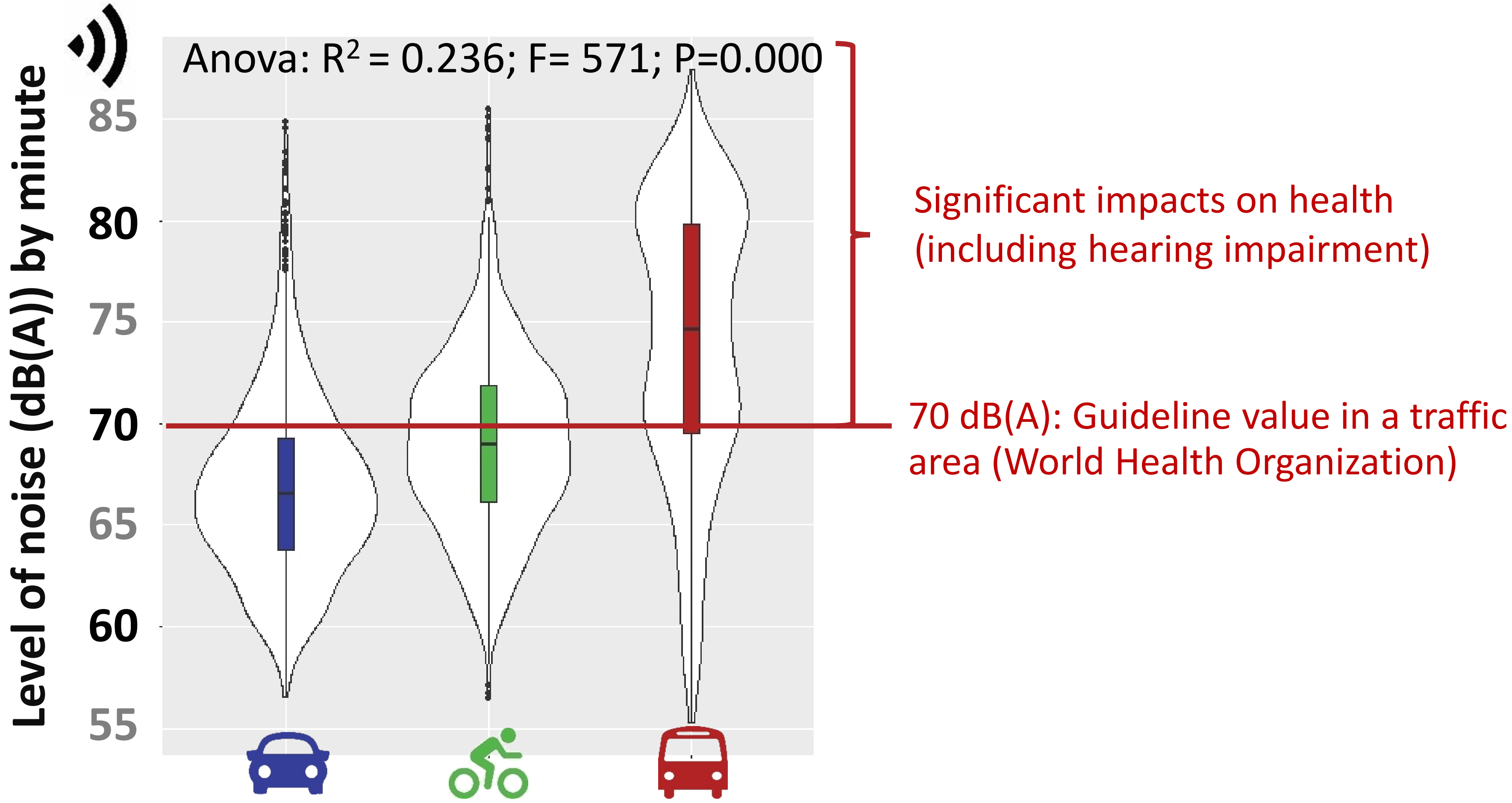
	Car	Bicycle	Bus
1st Quartile	25.8	28.7	31.0
Median	34.0	34.6	40.2
Mean	37.5	38.8	41.7
3rd Quartile	49.8	45.5	50.0

Travel time differences from car (min.)

	Bicycle	Bus
1st Quartile	-5.1	-2.4
Median	0.3	4.5
Mean	1.3	4.1
3rd Quartile	7.6	9.1

* Note: Differences in mean values are not significant at P=0.05 (Kruskal-Wallis test and Tukey Test).

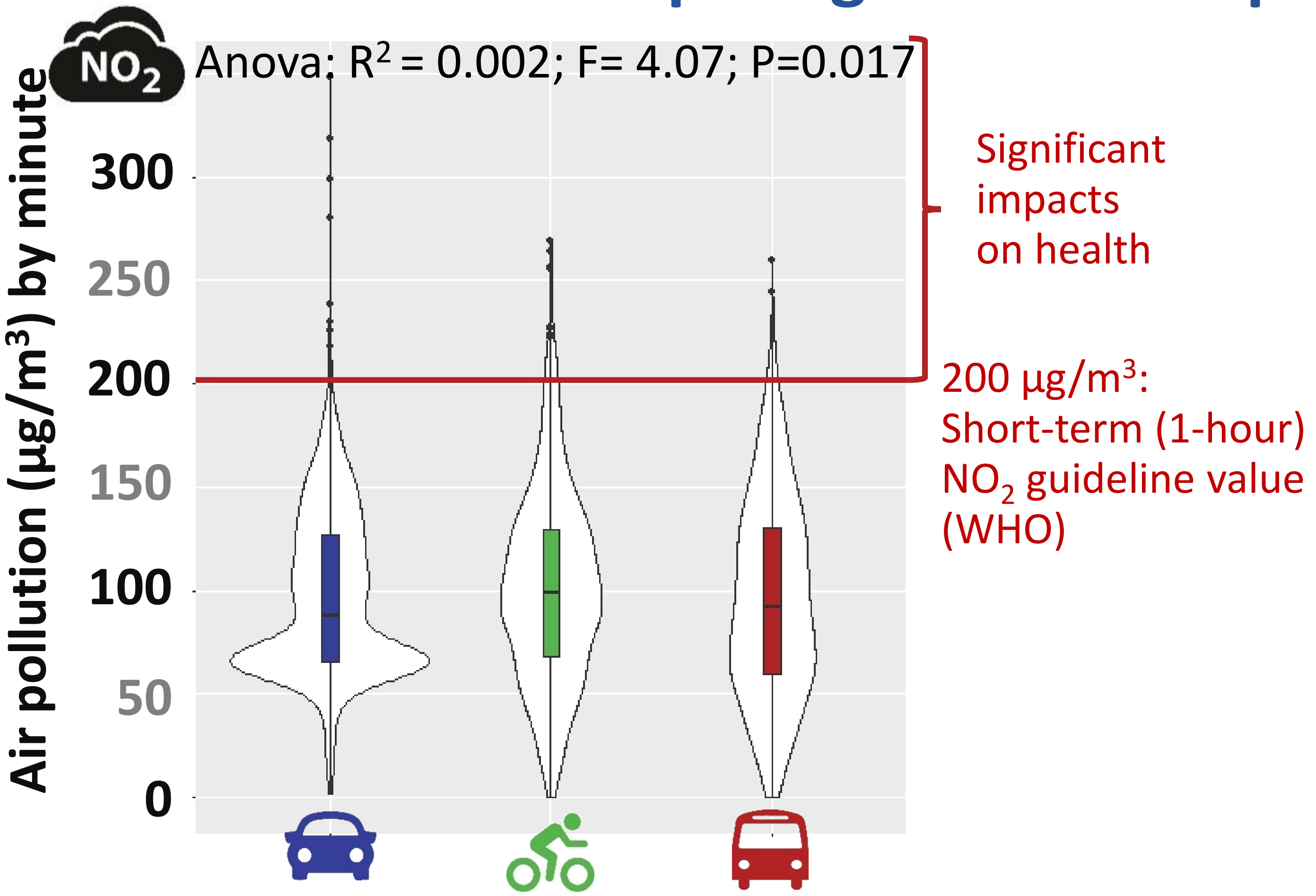
Results: Comparing Levels of Exposure to Road Traffic Noise

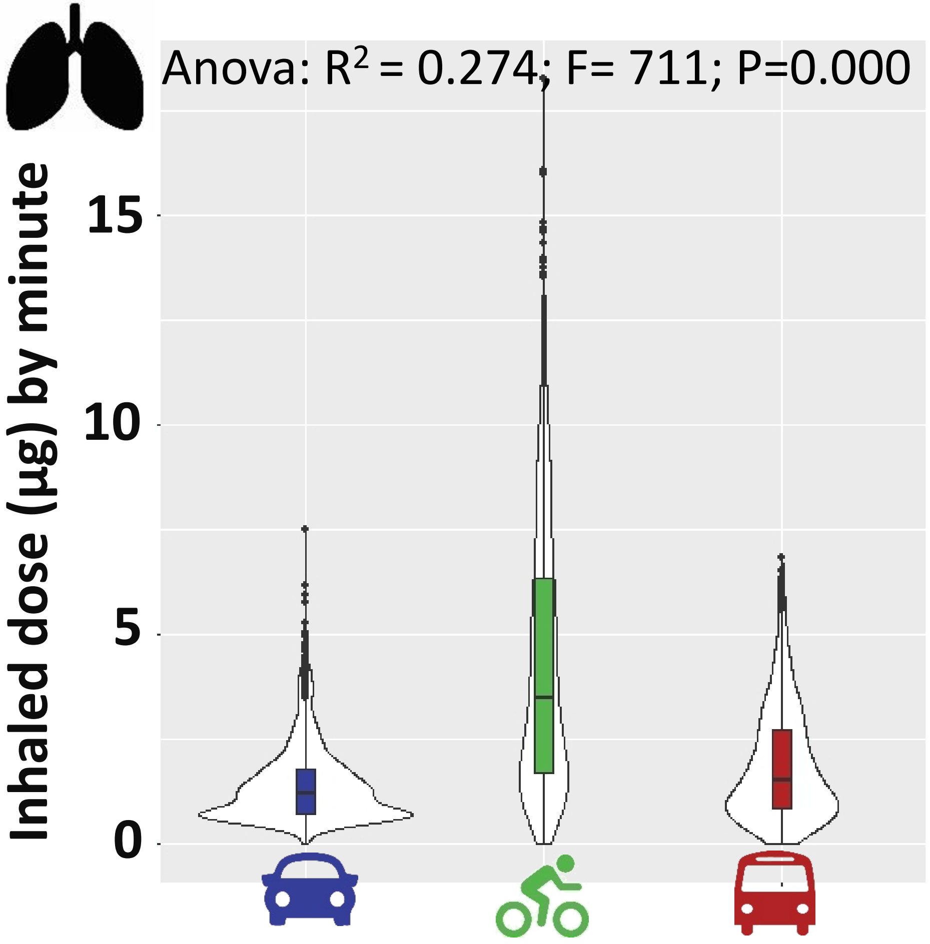


Mean	66.9	69.0	73.0
Difference from the mean by car	--	2.1*	6.1*

* Significant difference at P=0.01 (Tukey Test)

Results: Comparing Levels of Exposure to Air Pollution





Mean	97.4	101.0	96.1	1.43	4.32	1.88
Difference from the mean by car	--	3.6	-1.3	--	2.89*	0.45*

* Significant difference at P=0.01 (Tukey Test)

Mapping the Results: A Web-Atlas

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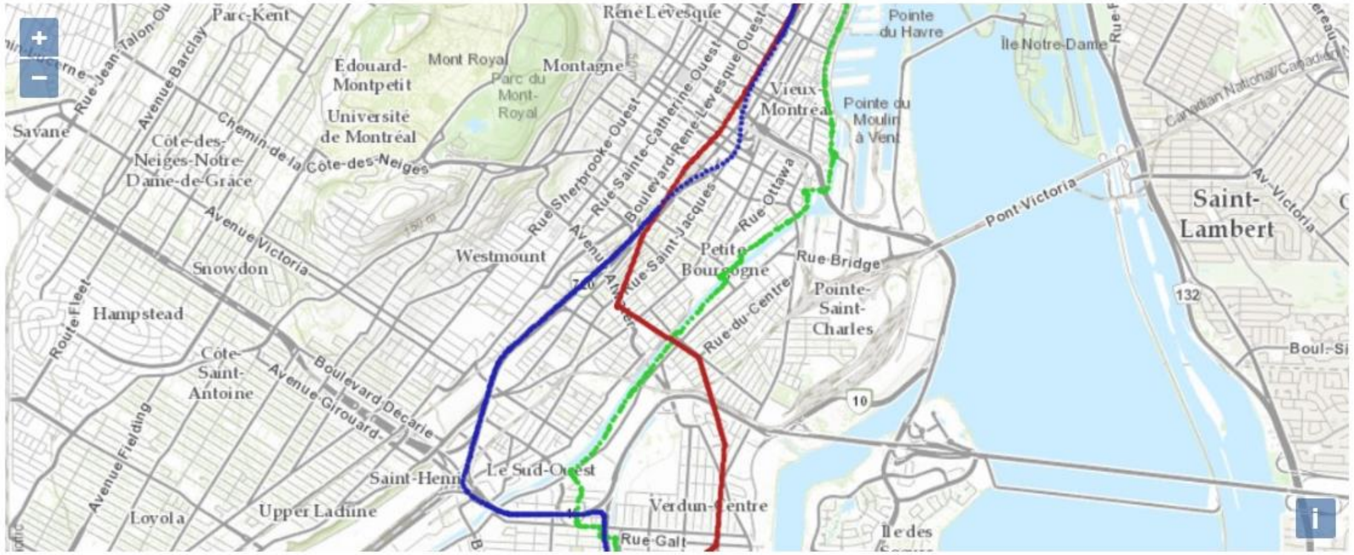
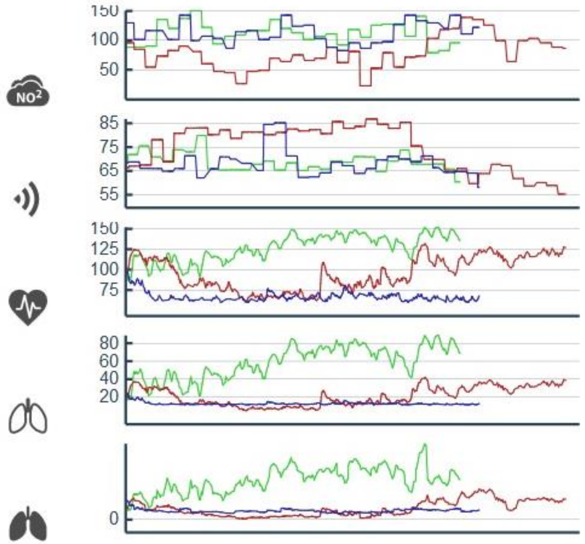
METHODOLOGY TRIPS

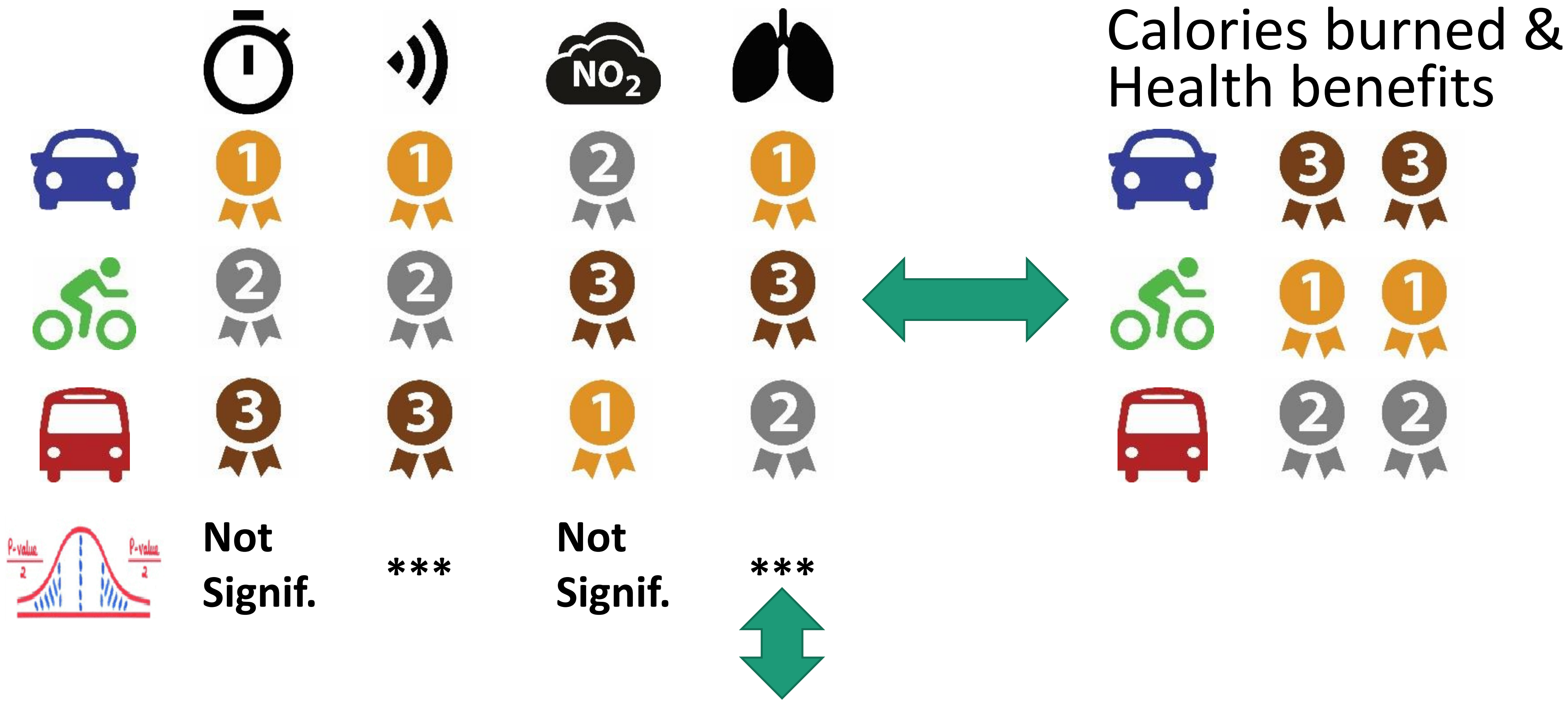




Comparison of the three trips

1	29"38	111	69	127	59	3060
2	31"21	115	69	67	13	832
3	39"1	72	78	92	19	1140

Concluding Remarks



- **Inhaled dose:** three times higher for cyclists than for car users
- Importance of measuring noise and the inhaled dose of air pollutant for cyclists, especially in cities with high levels of noise and air pollution

Future Work

Improvements in the methodological approach

- **Biometric T-Shirt (Hexoskin)**
  - Heart Rate & Breathing Rate & Minute Ventilation

Planned activities (2016-2017)

- Cyclists' exposure to air and noise pollution
  - **Mexico City (March 2016): 201 km collected**
  - Saigon (Vietnam) (July 2017)
  - Lyon (France) (October 2017)
  - Auckland & Christchurch (New Zealand) (???)

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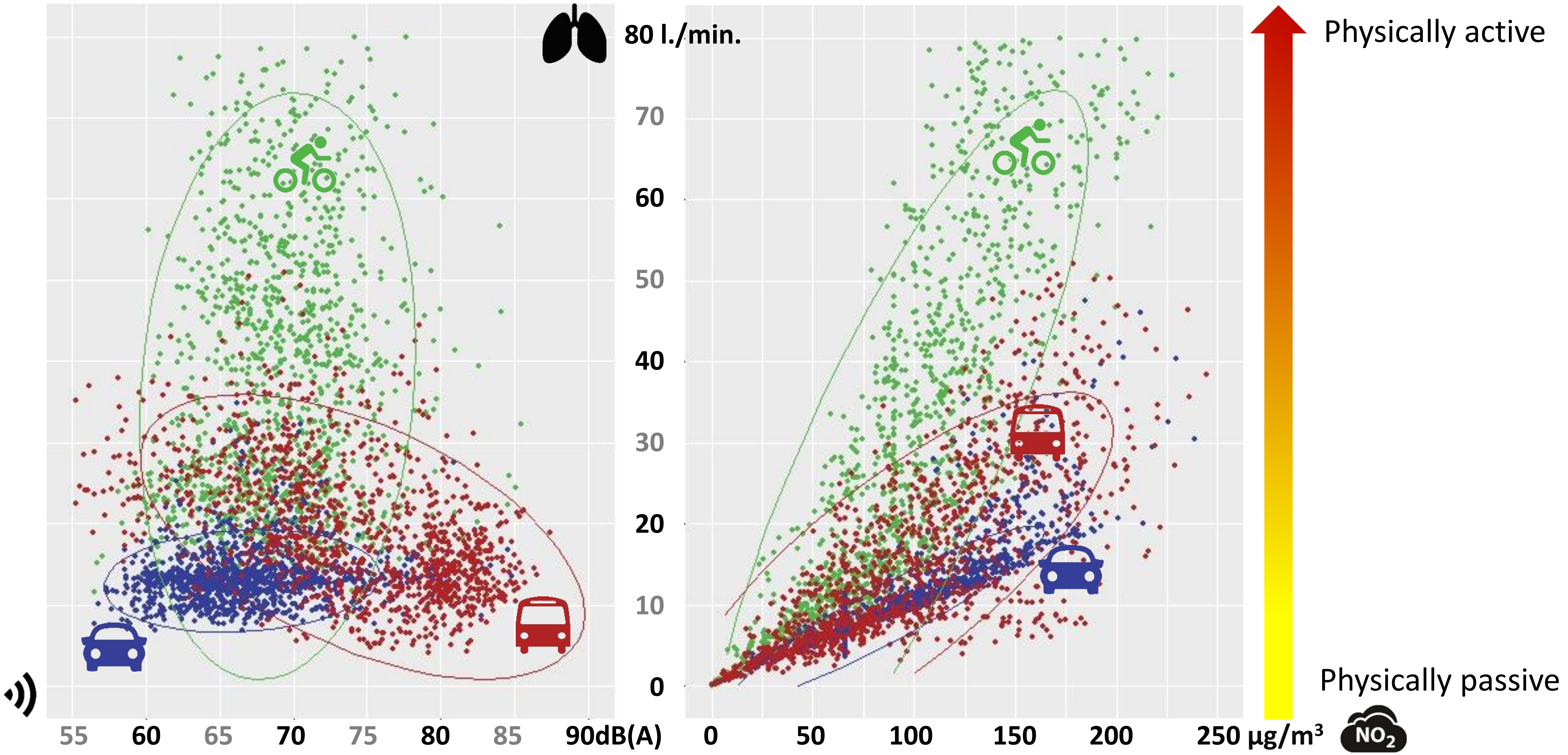

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Results: Comparing Travel Times

NO_2

	Car	Bicycle	Bus
1st Quartile	65.8	81.2	71.6
Median	88.7	102.8	82.3
Mean	97.4	101.0	96.1
3rd Quartile	115.6	125.4	115.2