A man in a dark t-shirt and light shorts is walking two dogs on a grassy field. One dog is black and the other is tan. In the background, there is a city skyline with several tall buildings under a clear sky. The scene is set in a park with trees and benches.

**Residential greenness contributes to physical activity behavior mainly in coronary artery bypass graft (CABG) patients not participating in cardiac rehabilitation**

**Maya Sadeh, MSc**  
**Graduate School of Medicine, Tel Aviv University**

## Study partners

This work was done as part of a Master's thesis supervised by:

**Prof. Rachel Dankner**, The Gertner Institute for Epidemiology and Health Policy Research and the School of Public Health, Sackler Faculty of Medicine, Tel Aviv University

**Other study partners include:**

**Dr. Alexandra Chudnovsky**, Geography Department, Tel Aviv University;

**Prof. Michael Brauer**, School of Population and Public Health, University of British Columbia;

**Arnona Ziv**, The Gertner Institute for Epidemiology and Health Policy Research;

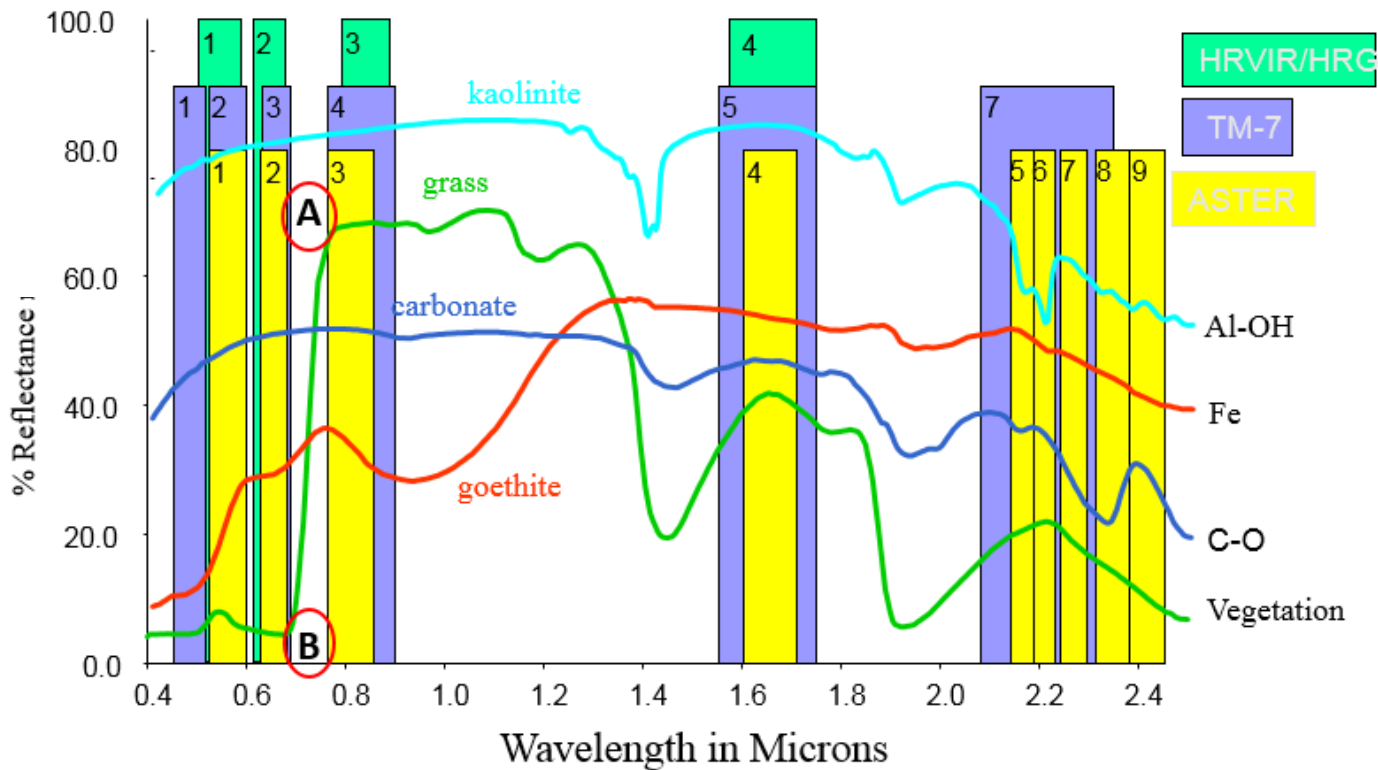
# Background – why are some people physically active and some people are not?

- Physical activity is related to improved quality of life and increased longevity among CVD patients (Kavanagh et al. 2002, Taylor et al. 2004).
- Ecological models of health behavior emphasize the environmental and policy context of behavior while incorporating social and psychological influences (Sallis et al. in “Health Behavior and Health Education” 4<sup>th</sup> edition).
- Biological pathways proposed to explain the association between green spaces and health: restoration, instoration and mitigation (Markevych et al. 2017). Focus on the restoration pathway related to health behaviors.

# Biological pathways

- Mitigation – **reducing harm**. E.g. reducing exposure to environmental stressors (air pollution, noise and heat)
- Restoration – **restoring capacities**. E.g. attention restoration, psychophysiological stress recovery
- Instoration – **Building capacities**. E.g. encouraging physical activity.

# Measuring greenness: The spectral signature of different surfaces



Beyond the  
human ability

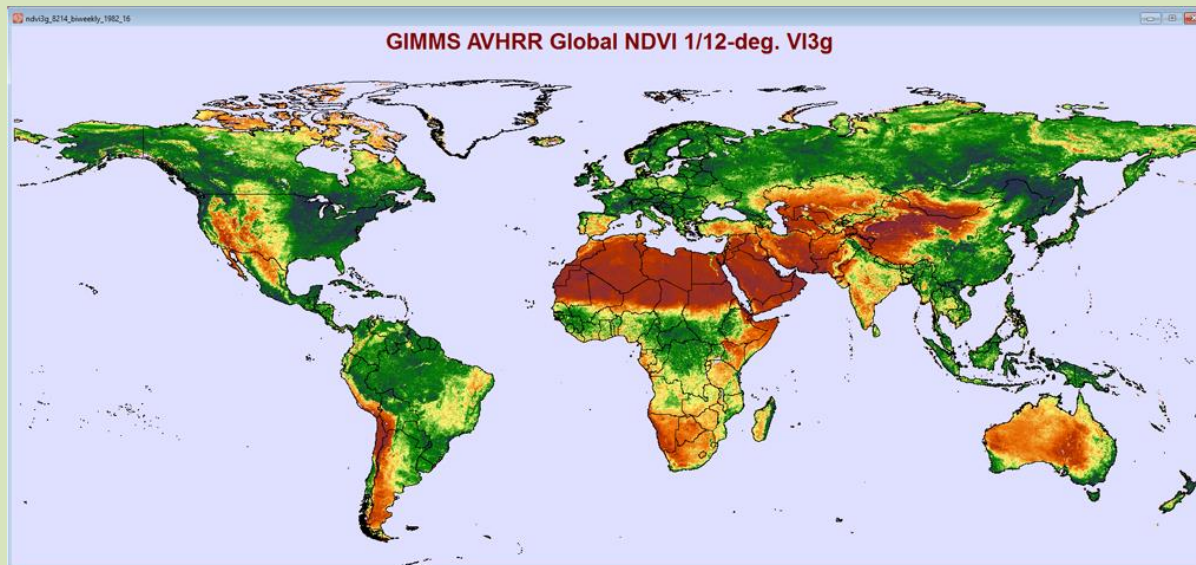




# Exposure to surrounding greenness

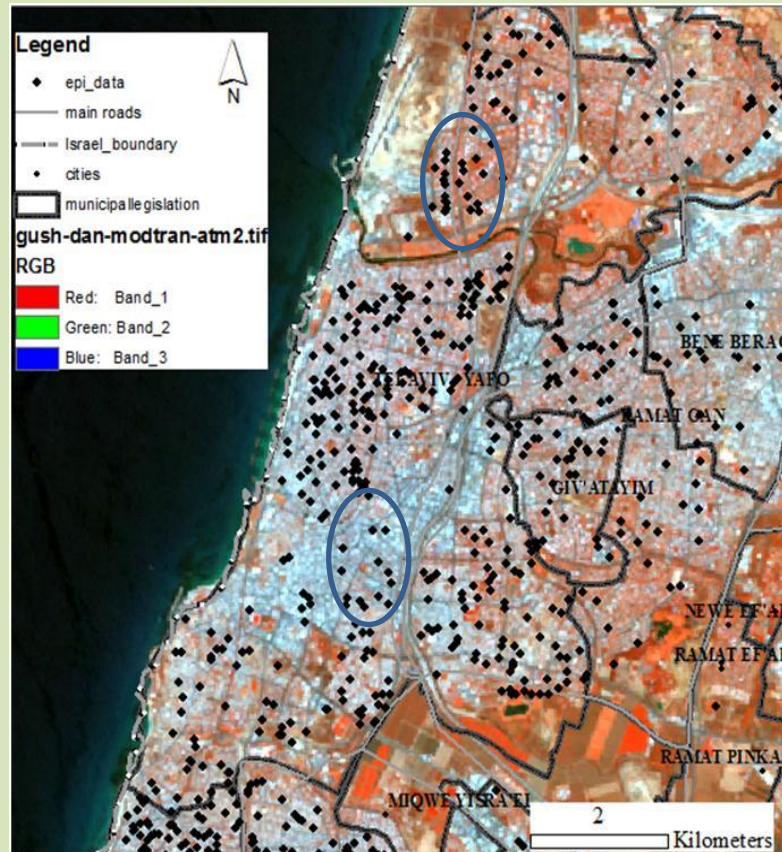
**Residential greenness** estimated using the Normalized Difference Vegetative Index (NDVI) calculated from LANDSAT satellite images from July 2002 in a spatial resolution of 30m<sup>2</sup>.

- $NDVI = (\rho^{NIR} - \rho^{RED}) / (\rho^{NIR} + \rho^{RED})$



# Objective

To study the association between level of residential greenness and sports related physical activity and physical fitness among a cohort of cardiac patients who underwent CABG surgery.



Atmospherically corrected Landsat 7 (June 14, 2003) false color composite image of part of the study area, the coastal urban area "Gush Dan" with superimposed population data. Vegetative/green space areas appear in red, urban area in cyan, sand in yellow.

# Objectives and study design

## **Aims**

- To study the temporal association between level of residential greenness at the time of surgery and sports-related physical activity status: active or sedentary behaviour, in a cohort of cardiac patients 1-year post CABG surgery adjusting for cardiac rehabilitation status

## **Study design**

A historical prospective cohort study



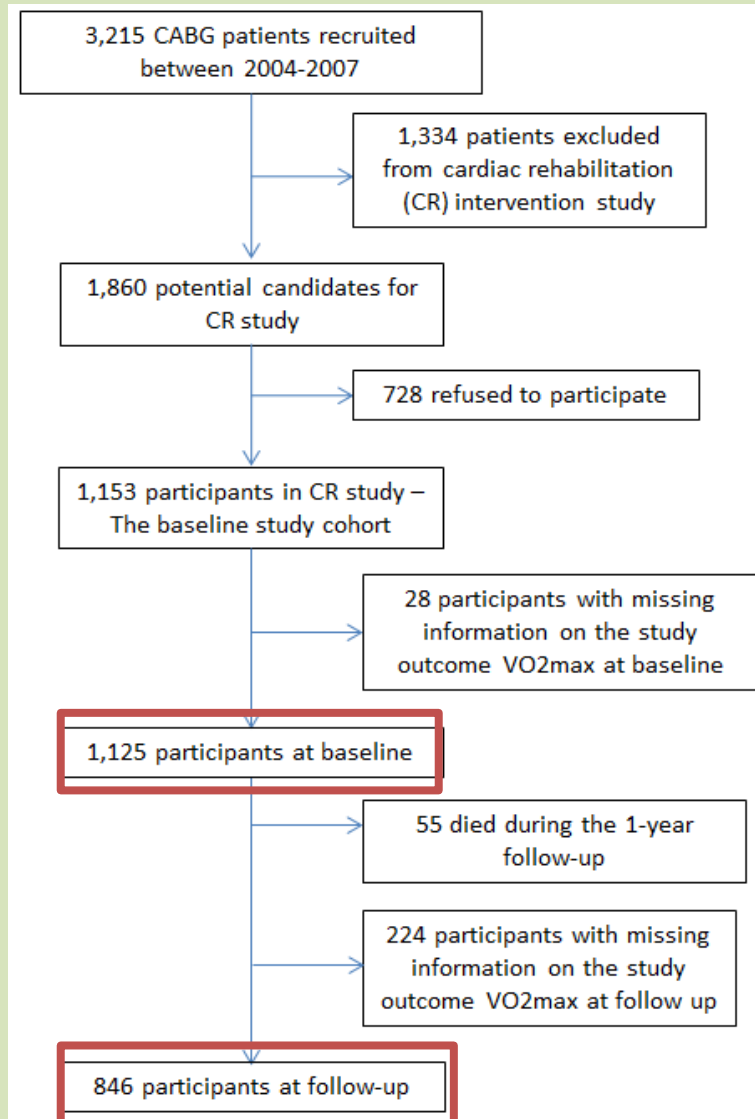
# Methods



# Study population

- A cohort of 846 patients out of 1,125 patients who underwent CABG surgery and participated in a cardiac rehabilitation (CR) intervention trial.
  - The cohort was recruited from a multicenter population of 3,215 patients who underwent CABG surgery at 7 cardiothoracic operating hospitals in Israel between the years 2004-2007.
- 
- ✓ Half of the study population received an intervention to encourage participation in CR
  - ✓ The population was interviewed twice: 1. before surgery 2. one year post-surgery
  - ✓ Information collected via questionnaires and measurement: demographics, socio-economic status, health status, health-related quality of life, cardiac rehabilitation  
+ information from the medical file

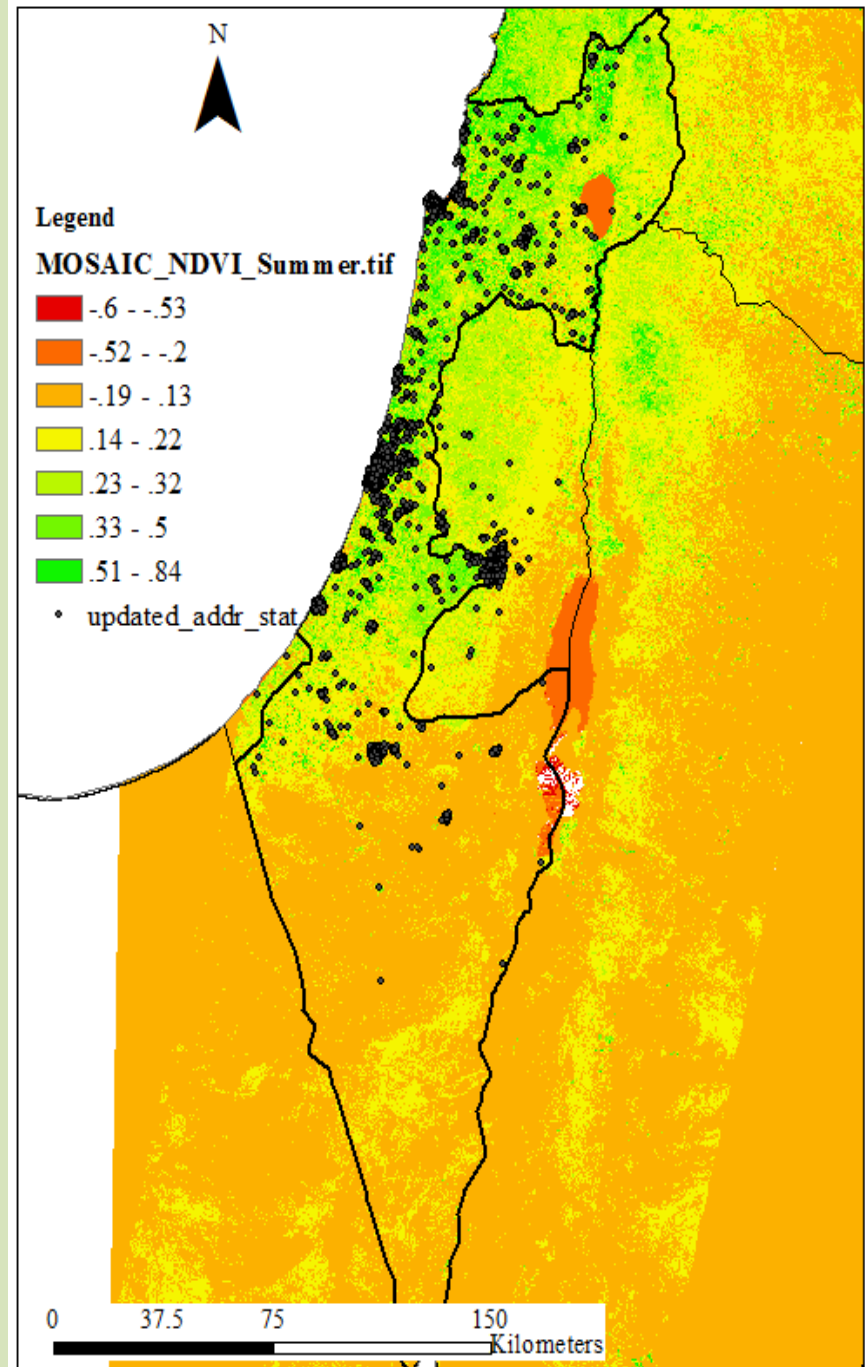
# The study cohort





# Study area

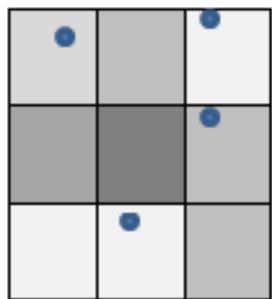
Residential addresses of the entire study population (n = 3,215) overlaid on an NDVI map. The green color represents areas with vegetation and orange areas represent no vegetation. The black circles represent residential addresses.



NDVI = Normalized Difference Vegetation Index

# The exposure assessment process in this study

- Geocoding of residential addresses
- Downloading images from “Landsat project ” satellites, USGS website. The date: July 30 2002 was chosen and pre-processed to provide reflectance data.
- NDVI was calculated in ArcGIS using “raster calculator”. Each patient gets the corresponding cell value of NDVI in the pixel (30m<sup>2</sup>) of their residential address.
- Creation of a 300m buffer around each address using ArcGIS and an average of the NDVI values of all pixels in the 300m buffer was calculated.



## Legend

NDVI = 1	
NDVI = 0.7	
NDVI = 0.2	
NDVI = -0.5	
NDVI = -1	

For Tel Aviv area:

Rich vegetation NDVI > 0.5

Presence of vegetation NDVI > 0.21

No vegetation NDVI < 0.07



# Outcome

**Sports-related physical activity** refers to participation in sports-related physical activity during one year preceding the interview.

- No sports-related physical activity: *Activity status* = “Sedentary”
- Any form or amount of sports-related physical activity: *Activity status*: “Active”



# Initial results





# Selected baseline characteristics of the study population by follow-up status

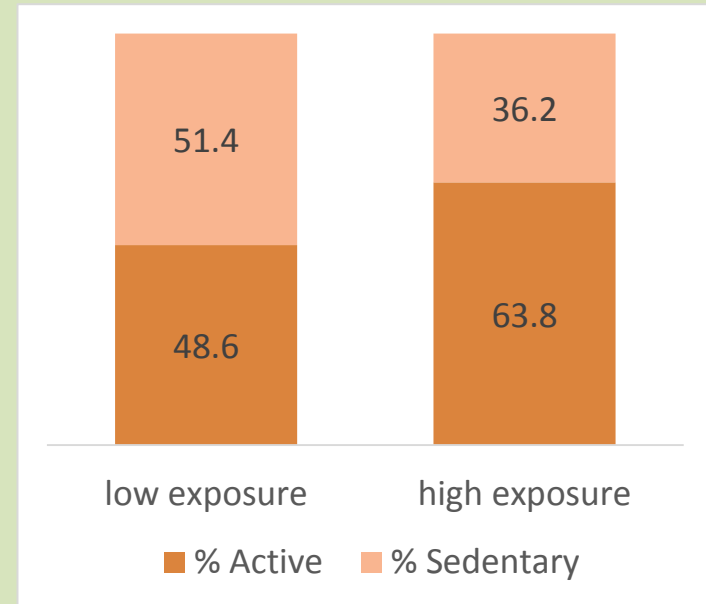
	Final cohort N = 846 (75.2%)	Lost to follow up N = 224 (19.9%)	Died within 1- year N = 55 (4.9%)	p-value
NDVI mean $\pm$ SD	0.168 $\pm$ 0.059	0.166 $\pm$ 0.061	0.161 $\pm$ 0.062	0.61
Sex (% women)	22.0	23.2	34.5	0.09
Age (years) mean $\pm$ SD				
men	64.4 $\pm$ 10.0	62.8 $\pm$ 11.2	70.8 $\pm$ 10.0	<0.001
women	69.7 $\pm$ 8.9	68.7 $\pm$ 10.5	74.4 $\pm$ 9.5	0.07
Religion (% Jewish)	94.3	88.8	92.6	<0.001
(% Muslim)	2.3	8.5	1.9	
BMI (kg/m <sup>2</sup> ) > 30 (%)	28.4	31.3	16.4	0.09
Hospital geographic area (% of patients)				<0.001
Gush Dan	65.1	54.9	54.5	
Jerusalem	14.2	7.6	10.9	
Haifa	15.1	15.6	20	
Beer-Sheva	5.6	21.9	14.5	

# Sports-related physical activity at baseline and follow up by exposure status

**Baseline**  $p = 0.06$



**Follow up**  $p < 0.001$

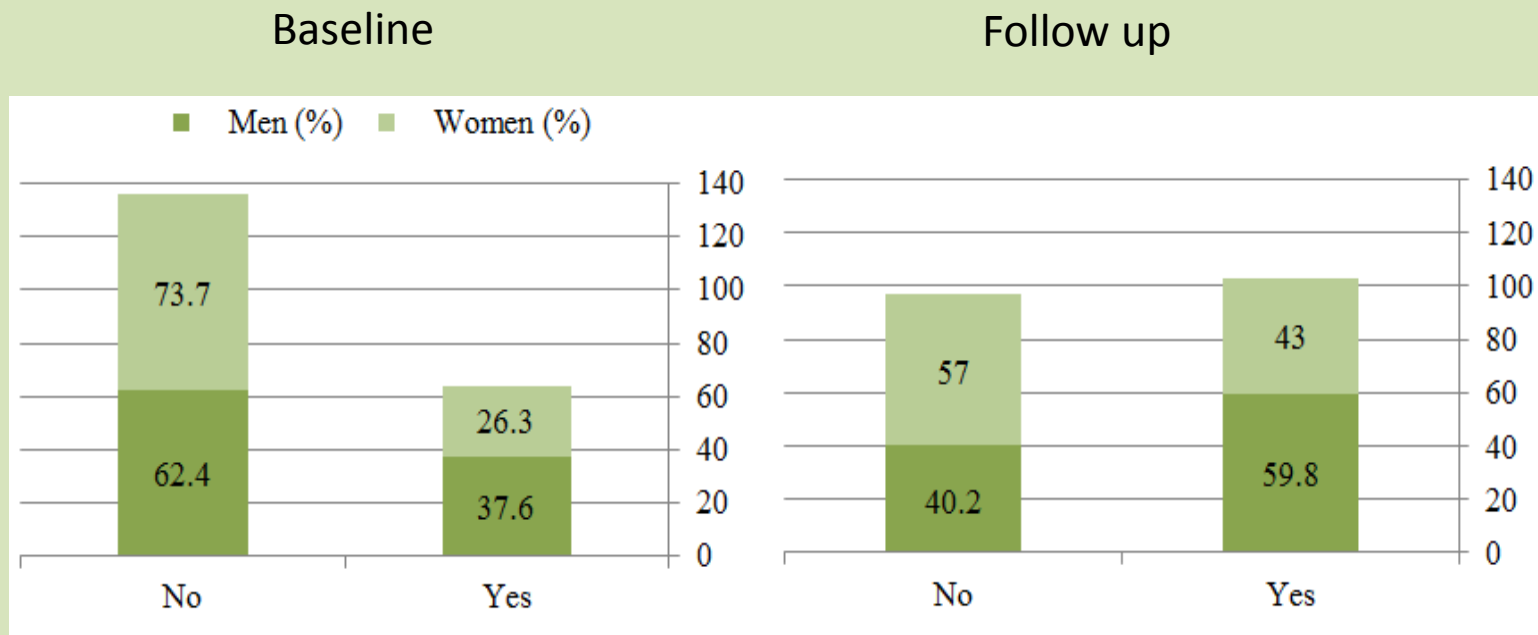


Low exposure:  $<$  median NDVI

High exposure:  $\geq$  median NDVI

median NDVI: 0.164

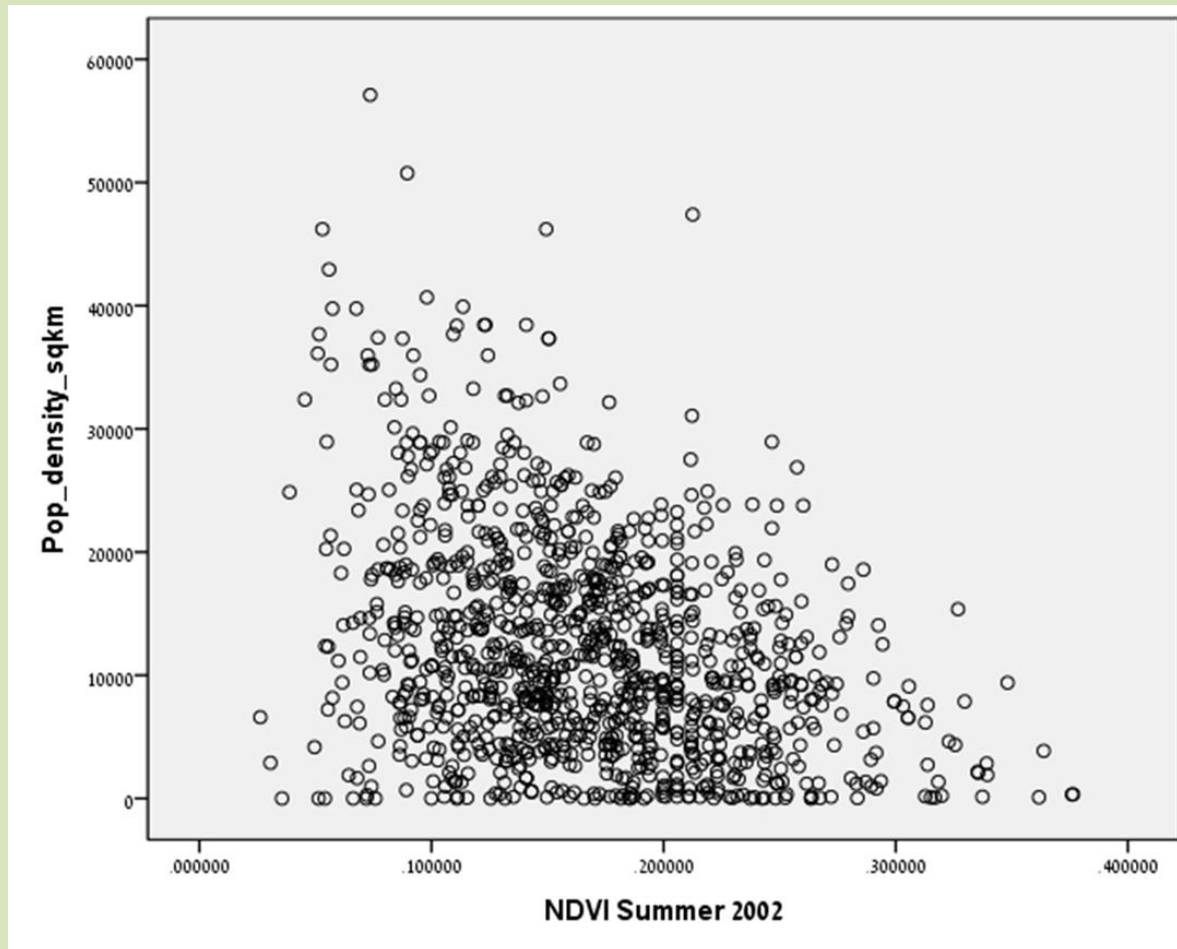
# Activity status at baseline and follow up by sex



p-value for difference in participation rate between baseline and follow up  
 $p < 0.001$  (McNemar's test)



# NDVI at 300m buffer around the patient's address versus population density at the residential address



$r = -0.329$   
 $P < 0.001$

## Discussion & conclusions

- This study's main strengths are its *novelty, cohort design* and *location*. Limitations include possible *outcome misclassification, external validity, and crude exposure measurement*.
- Our results have important implications for improved recovery of CABG patients and for CHD patients in general. Future studies should focus on the pathways underlying this relationship (types of physical activity, more specific attributes of the built environment).



# Thank you!

**Prof. Rachellie Dankner, Tel Aviv University; Dr. Alexandra Chudnovsky, Tel Aviv University; Prof. Michael Brauer, University of British Columbia; Dr. Joachim Heinrich, University Hospital Munich (LMU); Arnona Ziv, The Gertner Institute; The Environment and Health Fund, Israel**

