# Urban greenness and associations with obesity, physical activity, and health outcomes

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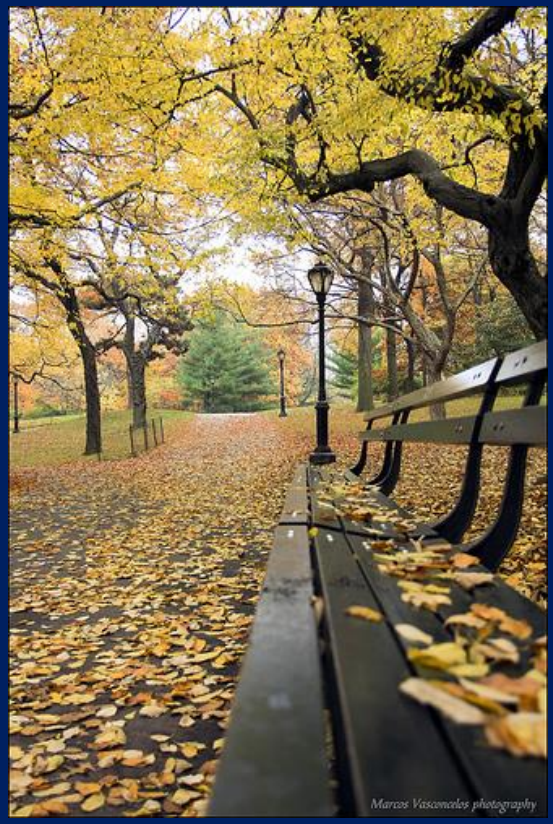
# Early Study of Greenness and Health (Ulrich et al, 1984)

- Compared survival among individuals undergoing surgery
- 46 patients (gall bladder surgery)
- Patients matched on number of factors (age, smoking, paint color, sex, hospital floor)
- Two windows views: bricks or trees
- Those with view of the trees had
  - Shorter stays
  - Less complaints
  - Fewer complications
  - Took less pain medication

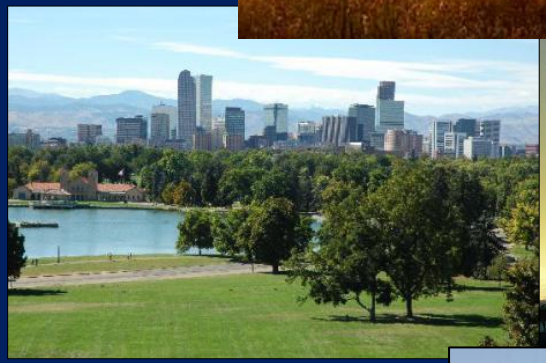
# Green Space and Health

- Largely ignored in environmental epidemiology are exposures that may have **positive** health benefits.
- In urban settings, access to green space shown to be related to wide variety of health outcomes
- Green space (or greenness) includes:
  - Access to parks
  - Vegetation
- Multiple pathways could be involved



# Environmental Impacts of Green Spaces

- Absorb air pollution
- Provide cooling
- Shelter from UV
- Reducing noise



# Green Spaces & Healthy Lifestyles

- Restoration from stress
- Time spent outdoors associated with several chronic conditions (obesity, HBP, heart disease, back and joint pain).
- Especially important for some (e.g., elderly, mothers with infants, children, those with disabilities)
- Enhancing Social networks
- Increased opportunity for physical activities

# Relevance of Physical Activity

- **Over 50% of Canadians are physically inactive *(Liu et al., 2008)***
- **Identified as the 4$^{th}$ leading global risk factor for mortality *(WHO 2014)***
- **Related to obesity**
- **Physical inactivity is a modifiable behaviour**

# Previous Studies of green space and physical activity and obesity

- Results have been inconsistent
- Systematic review of 50 studies (Lachowycz & Jones, 2013) found
  - Positive associations for 40% of studies of physical activity
  - Positive associations for 23% of studies of obesity
  - Variations in ability to control for other factors (residual confounding)
  - Green space was one of many exposures being examined (multiple testing)
  - Self-reports of physical activity & BMI
- Few attempts to characterize association on national-level

# National Scale Studies

- More generalizable
- Allow for a more socially and environmentally heterogeneous population to be captured
- Studies conducted in United Kingdom, Netherlands and New Zealand
- Relevance in terms of health promotion and policy development

# US and Canadian national studies

## Cross-sectional analyses

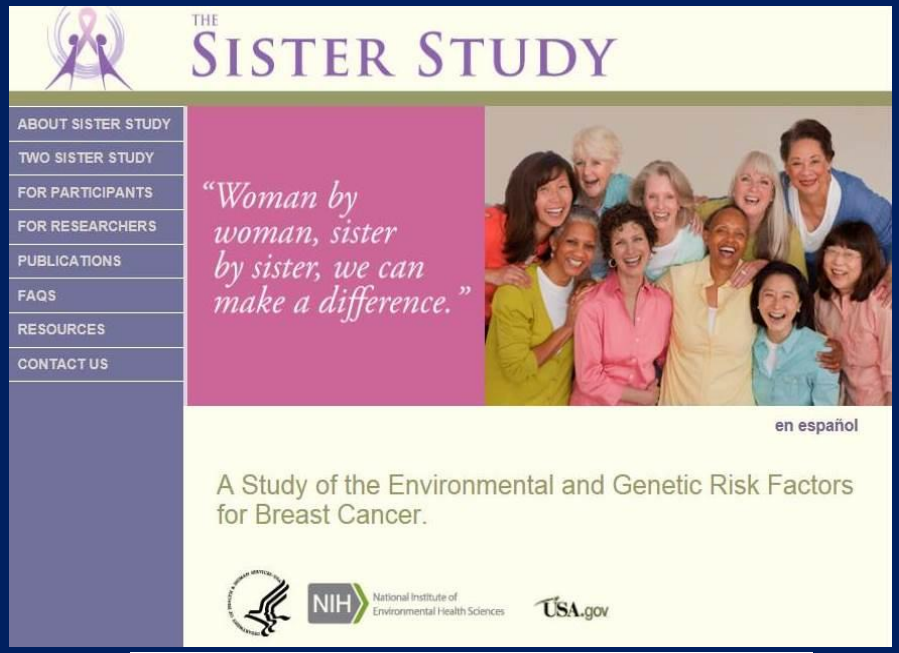
- US: Sister Study Cohort
- Canada: Canadian Community Health Survey

## Research Objectives

- To investigate associations between residential measures of green space and physical activity, and obesity
- Examine whether associations are modified by income

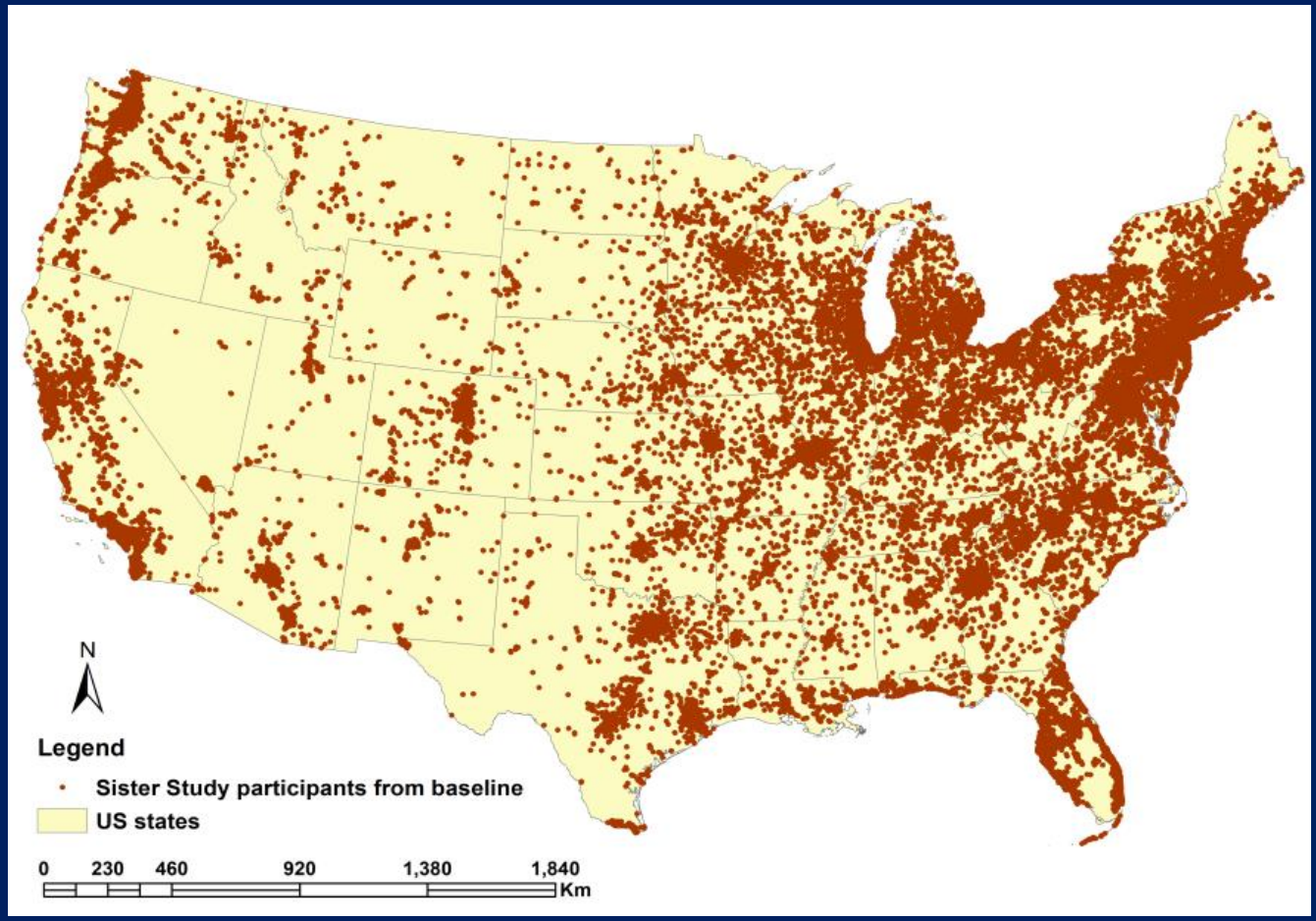
# The Sister Study

- conducted to better understand causes of breast cancer
- Participants: aged 35–74 and whose sister had breast cancer
- Enrollment opened in August 2003 and closed in July 2009.
- N= 50,884
- Participants completed computer-assisted telephone interviews at baseline
- The cohort will be followed for 10 or more years. Will evaluate factors that influence long-term survival and general health following breast cancer diagnosis and treatment.
- The study enrolled volunteers living in the US and Puerto Rico




www.sisterstudy.niehs.nih.gov

# Place of residence, Sister Study Participants



# Baseline data

- Demographic characteristics
- Environmental exposures
- Lifestyle factors including smoking, alcohol use
- Medical history, risk factors for breast cancer
- blood, urine, toenails, household dust

- BMI
  - Trained examiners measured participant's height and weight
- Physical activity:
  - included sports and exercise activities, other recreational activities and physically active chores during three time points: childhood, teenage years, and the past 12 months
- Residential data
  - Street address at baseline, childhood, and teenage years

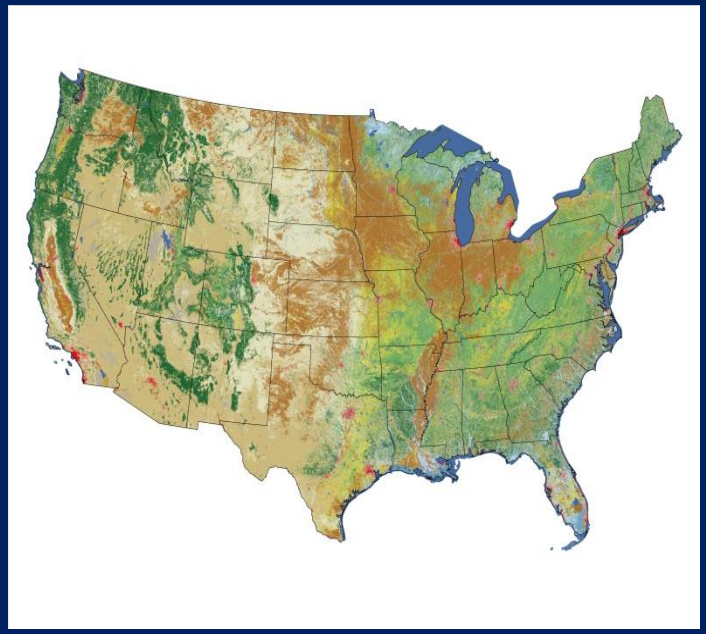
# Characteristics of participants

| Characteristic | | N | Mean | IQR |
|---|---|---|---|---|
| Age | | 50884 | 55.2 | 49.0 – 62.0 |
| BMI | | 50867 | 27.8 | 23.3 – 31.1 |
| PA – Met hrs/week | | 50838 | 50.7 | 23.1 – 67.2 |
| Household Income in US$ (per person) | | 48874 | 48874 | 18750 – 50000 |
| **Characteristic** | **Level** | **N** | **%** | |
| Ethnicity | White | 42558 | 83.7 | |
| | Black | 4462 | 8.8 | |
| | Other | 3849 | 7.5 | |
| Smoking status | Current | 4233 | 8.3 | |
| | Former | 19186 | 37.8 | |
| | Never | 27397 | 53.9 | |
| Marital Status | Married | 35870 | 70.5 | |
| | Never Married | 2759 | 5.4 | |
| | Divorced/Separated | 7550 | 14.8 | |
| | Widowed | 2564 | 5.0 | |

# Assignment of Green Space

## US National Land Cover database

- 16-class land cover classification scheme
- Applied across US
- Spatial resolution of up to 30m
- Based on Landsat retrieval (2006)
- Could assign measures to 97% of study subjects



# Assignment of Green Spaces

- Exposures assigned at 6 different spatial resolutions (30m, 250m, 500m, 1km, 2km, 5km)

| Exposure | Description |
|---|---|
| VEG1 | Forest (41, 42 and 43), shrubland (52) and herbaceous (71, 72 and 73) |
| VEG2 | Veg1 + Developed open space (These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.) |
| DHI | Developed high intensity (Examples include apartment complexes, row houses and commercial/industrial. Impervious surfaces account for 80% to 100% of the total cover) |
| IMP | % of surface that is Impervious |

# Pearson Correlation Coefficients

| | Veg 1 | Veg 2 | Impervious | Developed HI |
|---|---|---|---|---|
| **Veg 1** | 1.0 | 0.78 | -0.61 | -0.19 |
| **Veg 2** | | 1.0 | -0.74 | -0.31 |
| **Impervious** | | | 1.0 | 0.59 |
| **Developed HI** | | | | 1.0 |

- Analyses focused on vegetation indices
- Analyses across different buffer resolutions

# Statistical methods

- Logistic regression & General Linear Models analyses
- Spline analyses to look at nonlinear associations
- Obesity (BMI>35)
- Adjustment for other risk factors including
  - Income
  - Marital status
  - Smoking
  - Alcohol use
  - Race
- Stratified analyses by income, underlying health conditions

# Adjusted Odds Ratios, Green Space and Obesity (250 m buffer, Obesity=BMI>35)

| Vegetation Index | N | OR (1) | OR(1) |
|---|---|---|---|
| Low (0) | 21910 | 1.0 | 1.0 |
| >0 - < 6.9 | 6861 | 0.93 (0.86 – 1.01) | 0.97 (0.89 – 1.05) |
| 6.9 - < 18.8 | 6794 | 0.91 (0.84 – 0.99) | 0.99 (0.91 – 1.08) |
| 18.8 - < 42.2 | 7117 | 0.85 (0.79 – 0.93) | 0.93 (0.85 – 1.01) |
| High (>42.2) | 6862 | 0.74 (0.68 – 0.81) | 0.87 (0.80 – 0.95) |

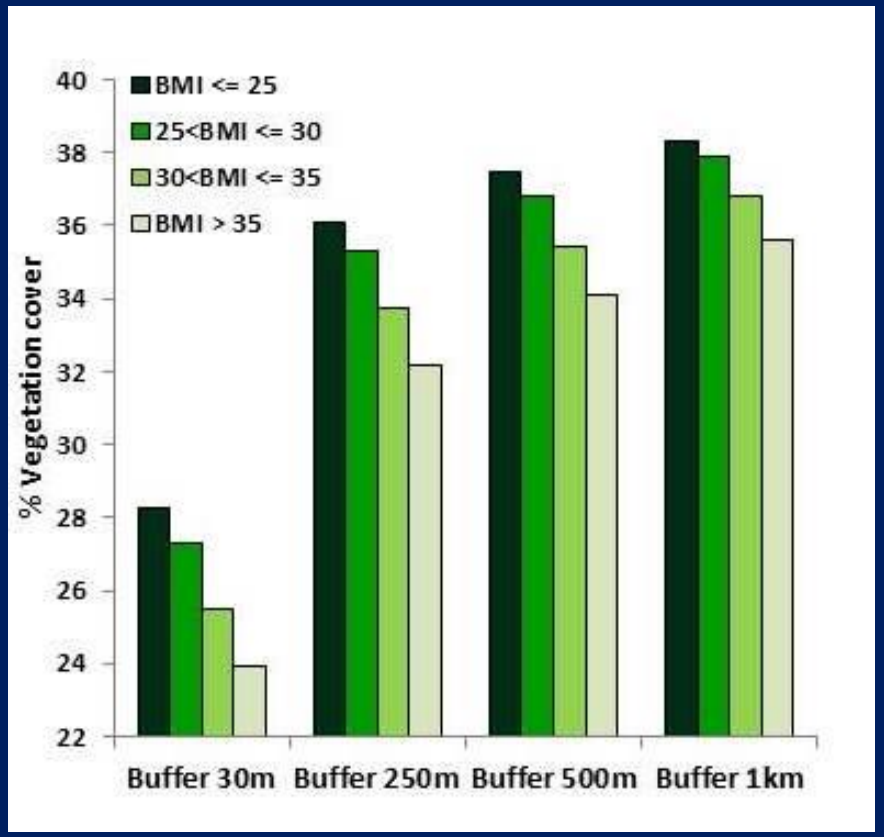
**OR(1) = adjusted for age**

**OR(2) Adjusted for: age, race, marital status, smoking, and income**

# BMI and Green space

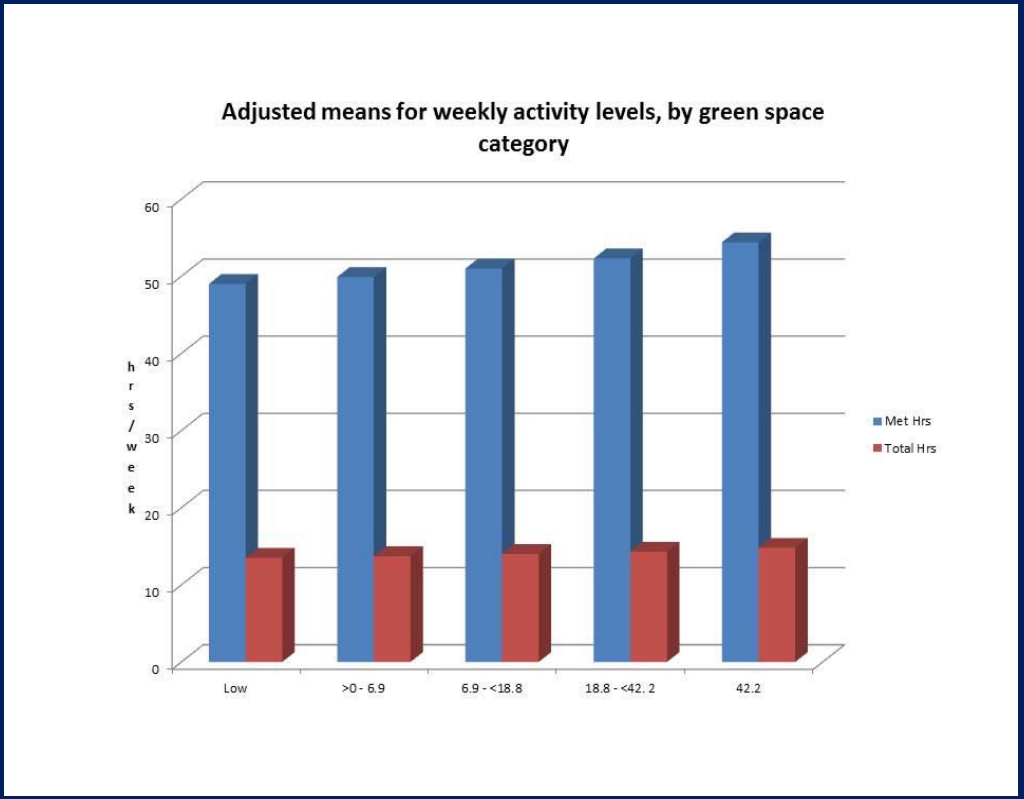
Varying Spatial resolutions

- % vegetation cover inversely associated with obesity
- Exposure-response pattern evident for all buffers considered



# Physical activity and green space

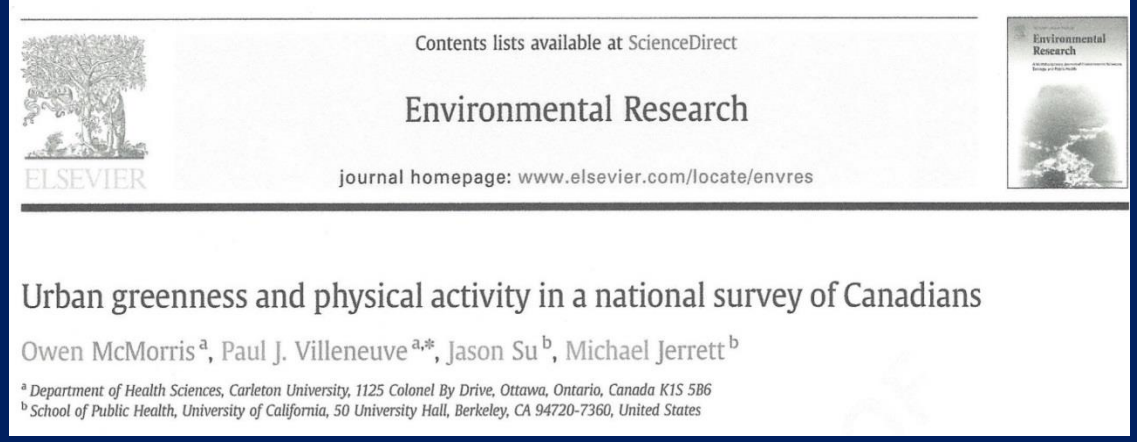
- Adjusted mean MET-hours/ week increased from 49.0 to 54.5 across green space categories
- Adjusted hours of physical activity increased from 13.5 to 14.8 across green space categories



# Conclusions

- Inverse associations between green space and measured BMI
- Inverse associations observed across different income groups; no effect modification evident (p=0.68)
- Positive association observed with levels of physical activity
- Additional analyses underway to look at
  - Associations with specific types of physical activity
  - Consider role of other factors (e.g., occupation)
  - Impact of obesity and activity patterns earlier in life
  - Nutrition

# What about Canada ?



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Urban greenness and physical activity in a national survey of Canadians

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## Cross-sectional analyses of the 2001 CCHS

- Voluntary, annual, national survey used for health surveillance and population health research (Statistics Canada, 2013)
- Demographics, physical activity variables, income adequacy levels available for participants
- Participation rates of ~ 80%
- Restricted to those in urban areas, and adults (20+ years of age)

# Assignment of Green Space

- Normal Difference Vegetation Index (NDVI)
- Used since 1973;
- Used to detect live green plant canopies in multispectral remote sensing data
- Derived from Landsat Thematic Mapper (1989 – 1997)
- Spatial Resolution of 30 m and 500m
- NDVI ranged from -1 (less green) to +1 (more green)
- Assigned to individuals 6 character postal codes

# Methods

- Sedentary behaviour set at 15 minutes or less of physical activity/day
- Logistic regression to determine any relationship between green space quartiles and sedentary activity (Repeated for green space and obesity- BMI 30+)
- Logistic regression for green space and sedentary activity between income adequacy and age groups


N
Legend
Ottawa ND
High : 1.00
Low : -1.00

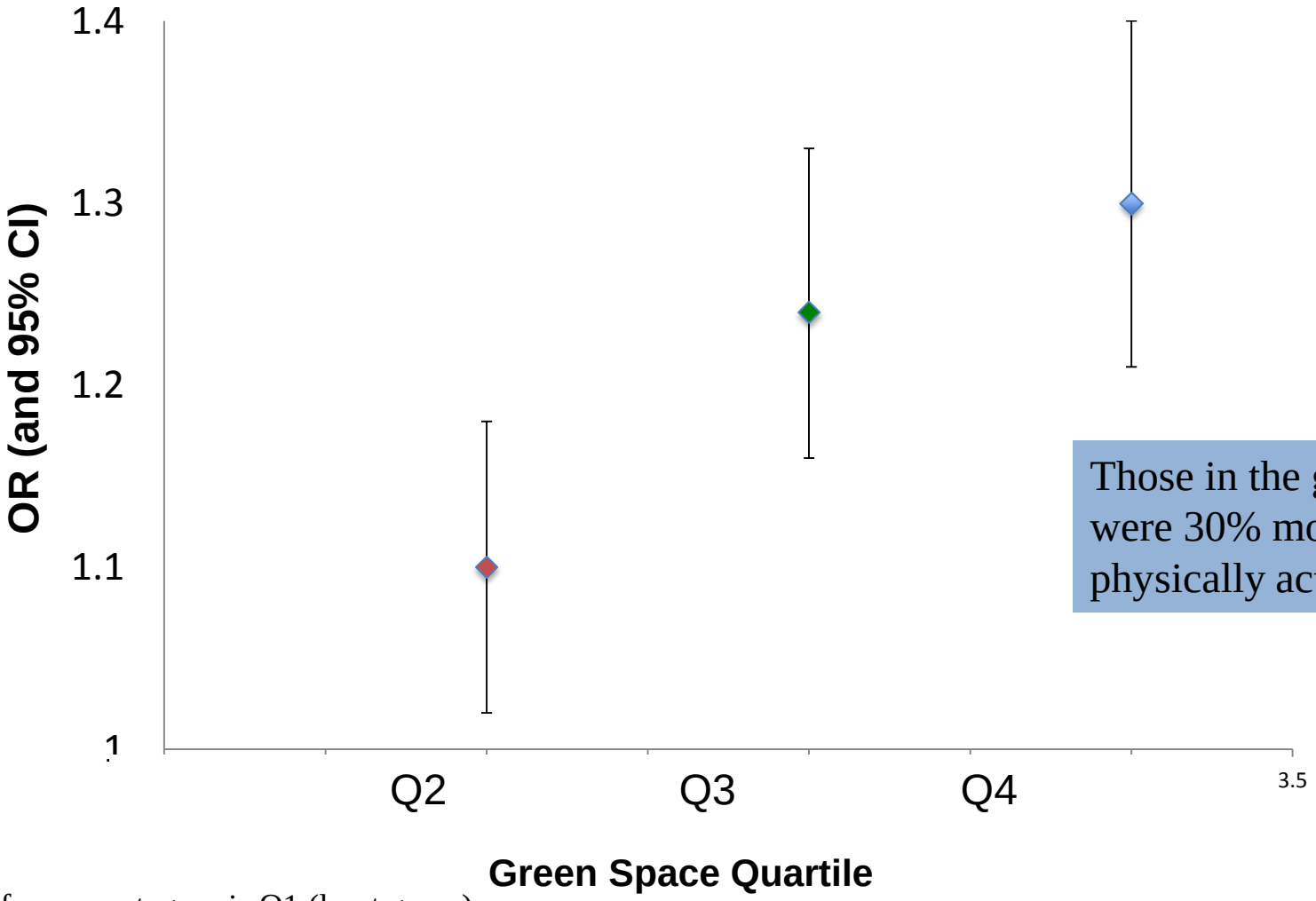
# Descriptive characteristics

| **Sex** | **N** | **%** | **MeanNDVI** 0 1 |
|---|---|---|---|
| Male | 31299 | 44.8 |  |
| Female | 38611 | 55.2 |  |
| **Age** | | | |
| 20-29 | 10767 | 15.4 |  |
| 30-39 | 14450 | 20.7 |  |
| 40-49 | 15100 | 21.6 |  |
| 50-59 | 11119 | 15.9 |  |
| 60+ | 18474 | 26.4 |  |
| **Income Adequacy** | | | |
| 1 (Lowest) | 3010 | 1.3 |  |
| 2 | 5953 | 8.5 |  |
| 3 | 14466 | 20.7 |  |
| 4 | 22627 | 32.4 |  |
| 5 (Highest) | 17481 | 25.0 |  |

# Descriptive characteristics

| **Smoking Status** | **N** | **%** | **MeanNDVI** 0 1 |
|---|---|---|---|
| Daily | 16474 | 23.6 |  |
| Occasional | 2836 | 4.1 |  |
| Non-smoker | 50577 | 72.4 |  |
| **Marital Status** | | | |
| Married | 35217 | 50.4 |  |
| Common-Law | 5395 | 7.7 |  |
| Widowed | 7000 | 10.0 |  |
| Divorced/ Separated | 8271 | 11.8 |  |
| Single | 13949 | 20.0 |  |
| **Region** | | | |
| Western Canada | 19138 | 27.4 |  |
| Prairies | 5733 | 8.2 |  |
| Central Canada | 38186 | 54.6 |  |
| Maritimes | 6853 | 9.8 |  |
| **Total Population** | 69910 | 100 |  |

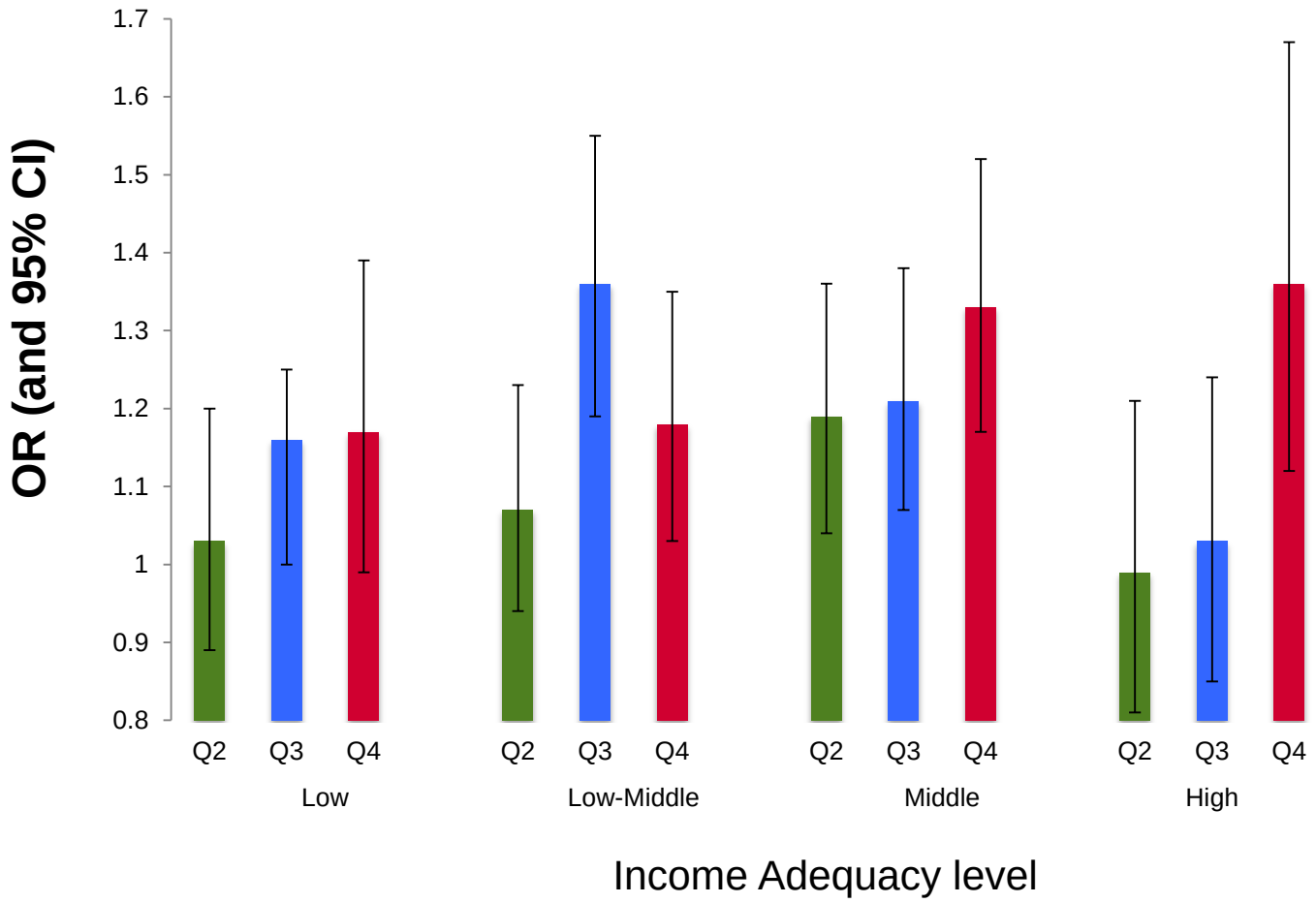
# Adjusted Odds ratio of participating in leisure-time physical activity by quartile of green space




Those in the greenest quartile were 30% more likely to be physically active

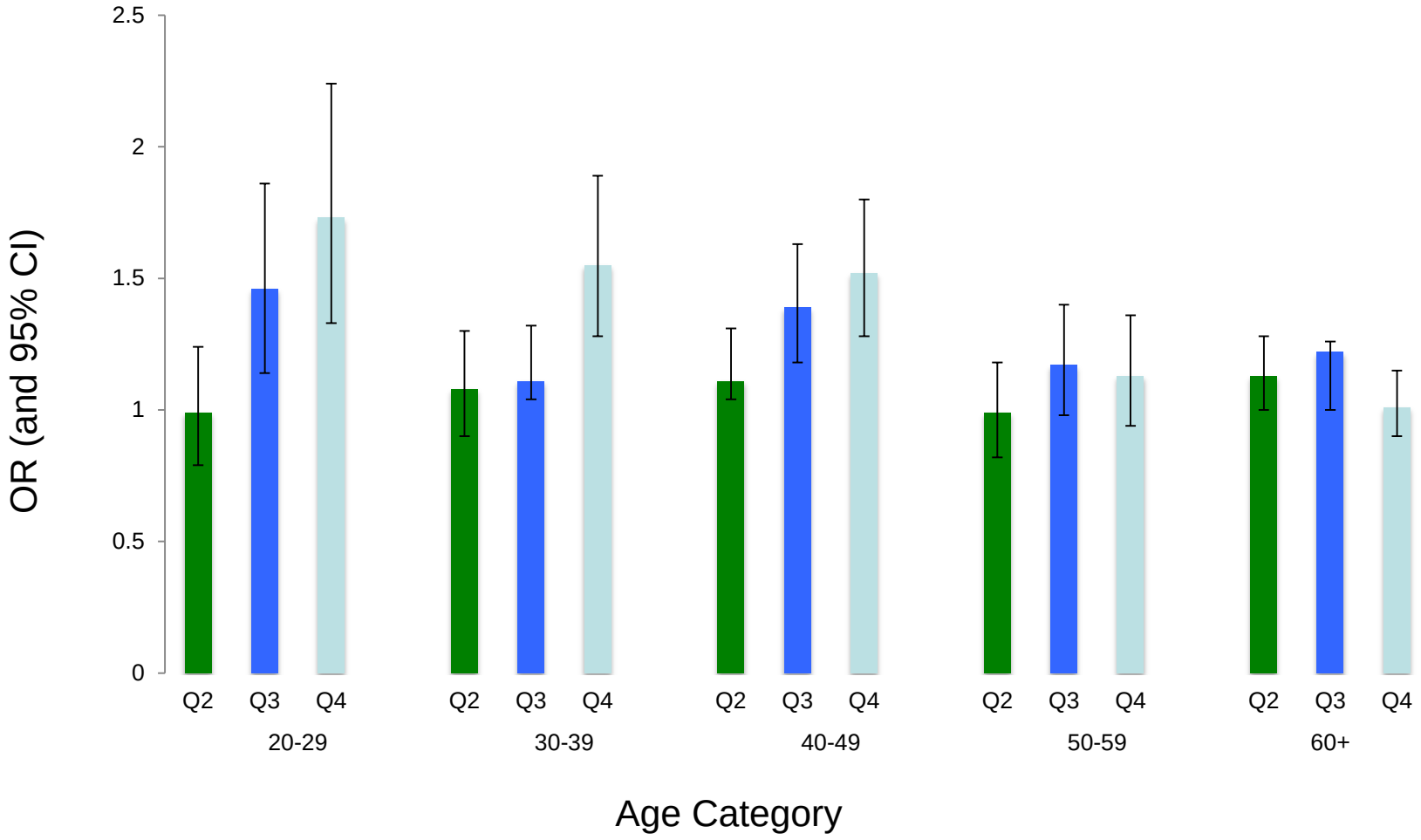
Reference category is Q1 (least green)
Adjusted for age, sex, smoking status, marital status, latitude & longitude

# Adjusted odds ratios of participating in leisure physical activity across green space quartiles, by income level



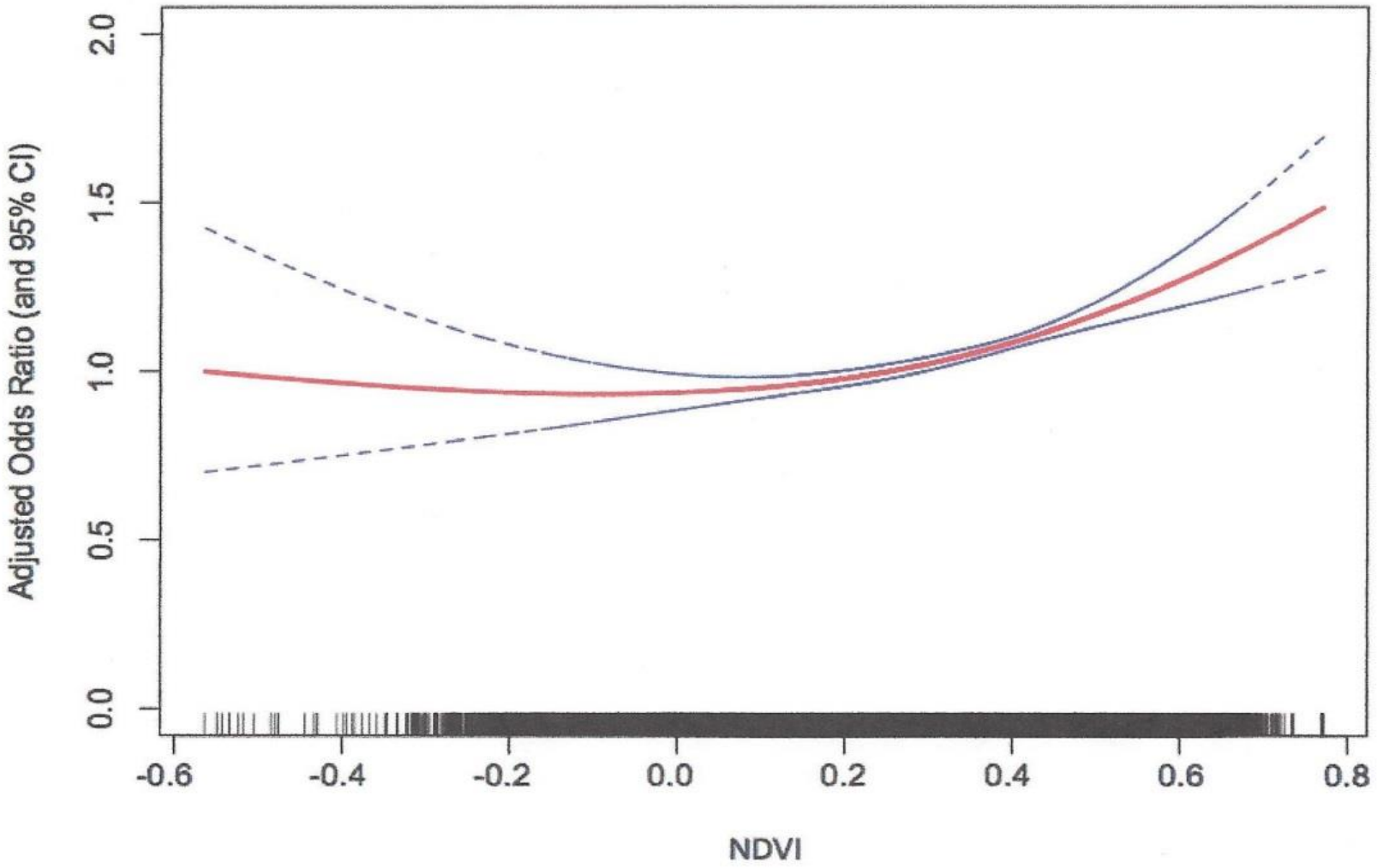

Reference category is Q1 (least green)
Adjusted for age, sex, smoking status, marital status, latitude & longitude

# Adjusted Odds ratios of participating in leisure physical activity across green space quartiles, stratified by age




Reference category is Q1 (least green)
Adjusted for age, sex, smoking status, income adequacy, marital status, latitude & longitude

**Figure 1: Adjusted Odds ratios for participating in leisure physical activity in green space in relation to the lowest green space level for urban subjects, 20 years of age and older who participated in the 2001 Canadian Community Health Survey**




NDVI data transformed to positive values for analysis

# Conclusions

- Green space positively associated with physical activity independent of income
- Association strongest among young adults
- Creating and maintaining urban green space may help improve participation in physical activity among urban Canadian adults

# Access to Green Space and other Health Measures in Canadians

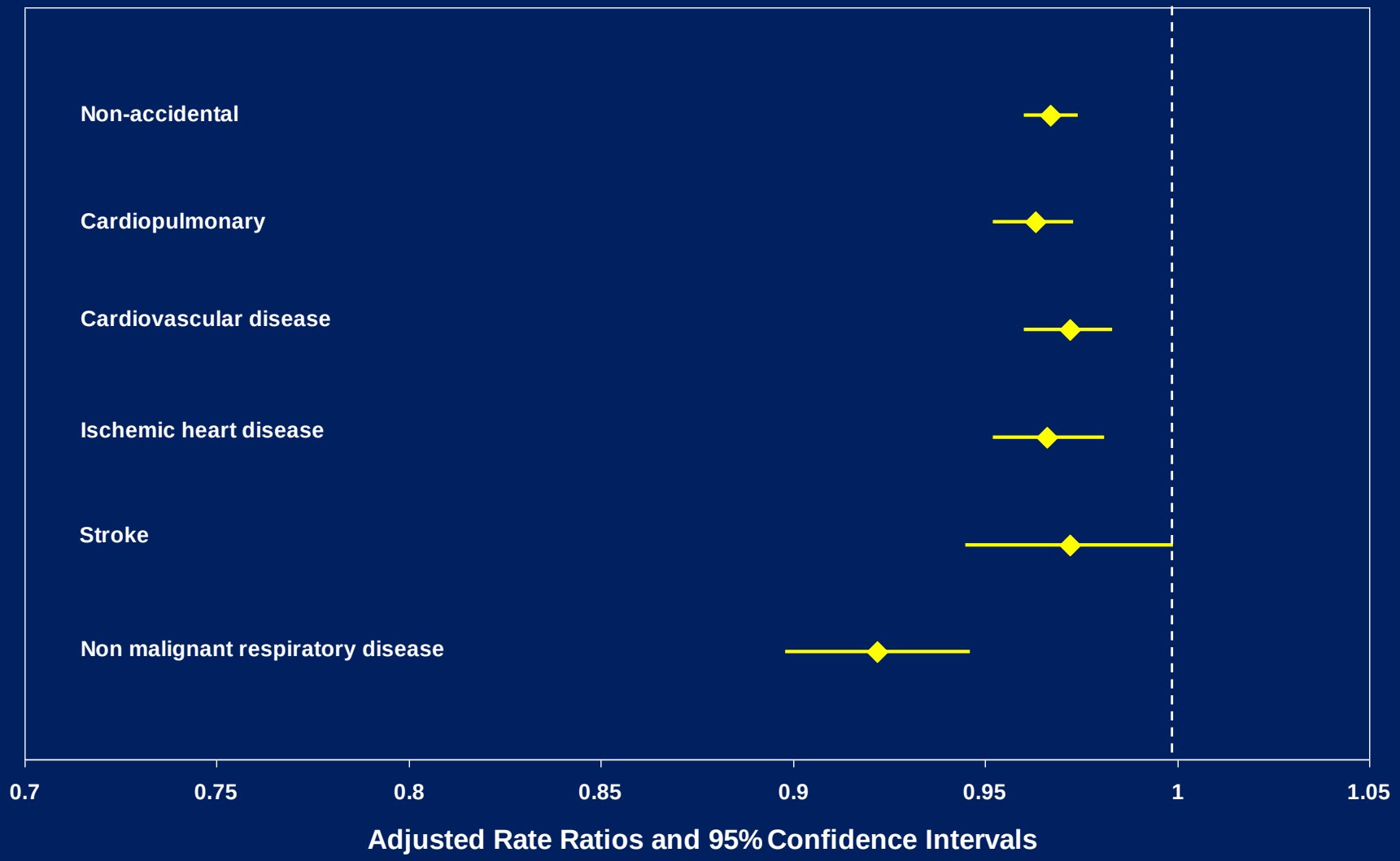
- Very few studies
- Associations noted with
  - Mortality
  - Pregnancy Outcomes

# Greenness and mortality

- Ontario Tax Cohort (Villeneuve et al, 2012)
- Identified from Statistics Canada's T1FF income tax filing (>95% coverage)
- Cohort of ~ 600,000 Ontario residents
  - Age 35+
  - Linked to Canadian mortality database
  - Lived in one of 10 Ontario centres
  - Followed between 1981 and 2004
- Assigned NDVI to postal code at place of residence at entry


Thunder Bay
Lake Superior
Province of Ontario
Greater Sudbury
Manitoulin Island
Ottawa
Ottawa
Kingston
Michigan
Wisconsin
Toronto
Toronto
Lake Michigan
Milwaukee
Hamilton
St. Catharines - Niagara
Sarnia
London
Detroit
Windsor
Chicago

**Figure 1: Adjusted RRs and 95% C.I.'s per increase in the interquartile range of the Normalized Difference Vegetative Index, by underlying cause of death,**




*** RRs were adjusted for age, sex, household income, marital status, and area measures of income, immigration, unemployment and ambient $PM_{2.5}$**

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Research | Children's Health

# Residential Greenness and Birth Outcomes: Evaluating the Influence of Spatially Correlated Built-Environment Factors

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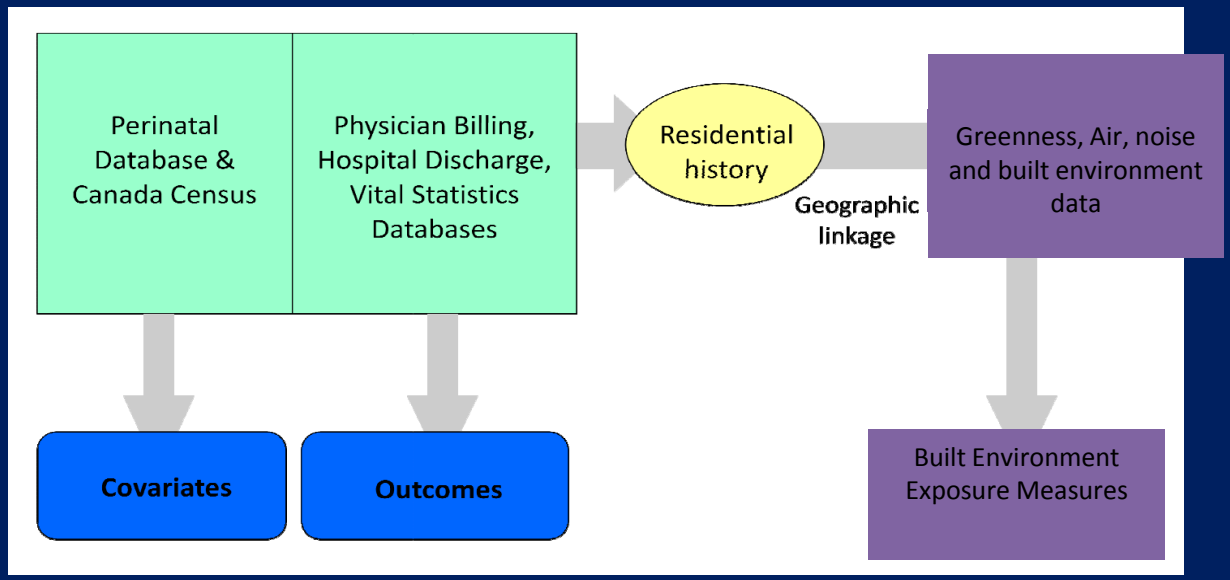
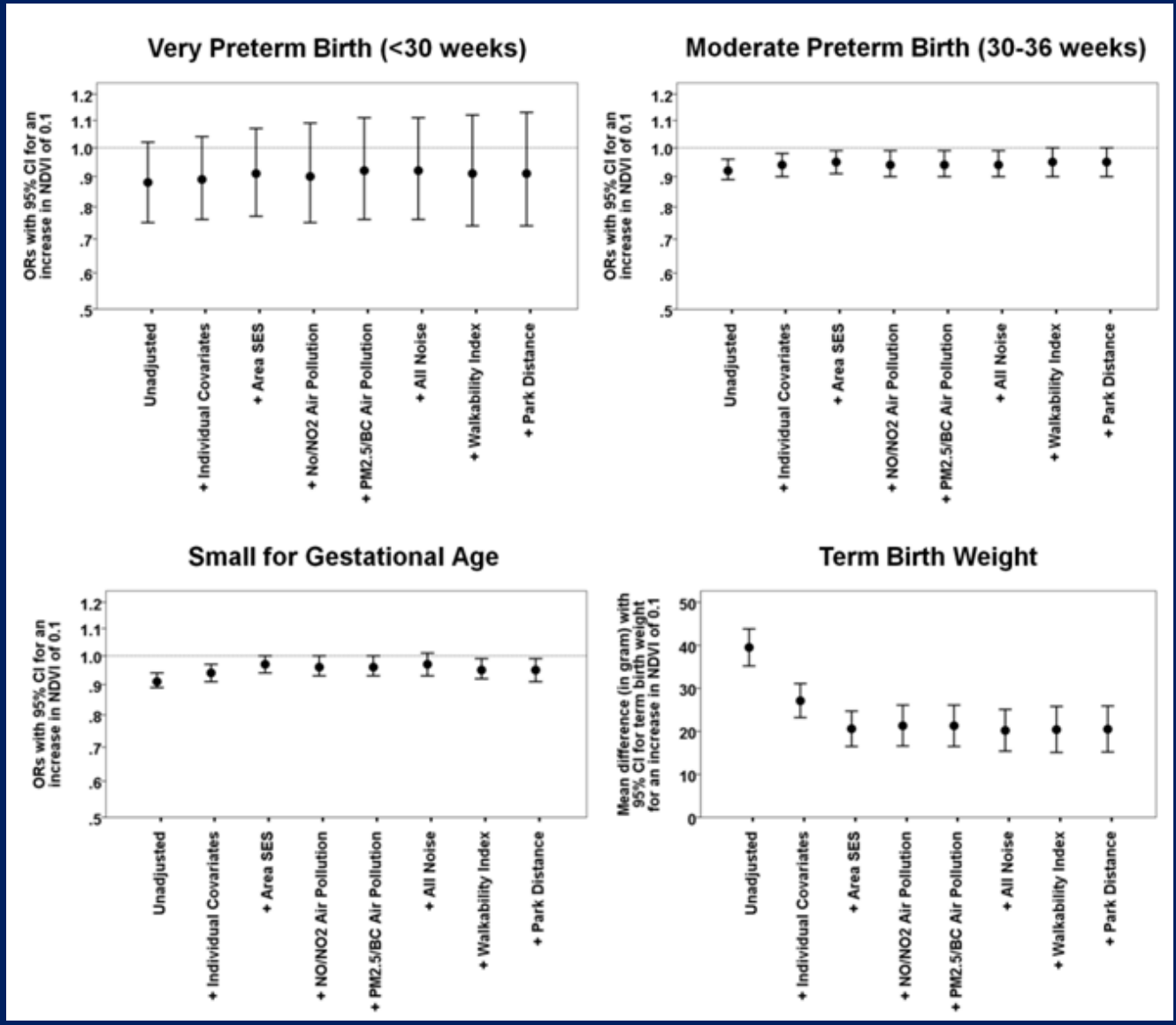
- Birth cohort identified 92,158 children born in the Vancouver metropolitan area from 1999–2002.




- *34.9 % of cohort had 2 addresses during pregnancy.*
- *81% of mothers had complete residential history (9 months of pregnancy).*

# Joint Exposures – Greenness and Birth Outcome Associations



# Where to go from here….

1. Do healthy people choose to live in green areas, or do green areas make people healthier?

2. Do certain characteristics of green space offer more benefits?

3. What are the nature of the associations using more refined measures of physical activity, and spatial monitoring?

# Collaborators

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Scott Weichenthal, *Health Canada*
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Thank –you!

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