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Living Near Greener Spaces is Associated with Lower Risk of Diabetes-Related Mortality in Brussels, Belgium: a 13-Year Mortality Follow-up Study

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INTRODUCTION

Introduction

- Indicative evidence of a relationship between exposure to residential urban green spaces (UGS) and diabetes

Astell-Burt, 2014; Bodicoat, 2014; Ngom, 2016; den Braver, 2018.

- Mechanisms:
  - Increased opportunities for physical activity
  - Restoration and stress reduction, improved mental health
  - Mitigation of environmental hazards (e.g. air pollution)
  - Modulation of immune responses through cell signaling inhibition

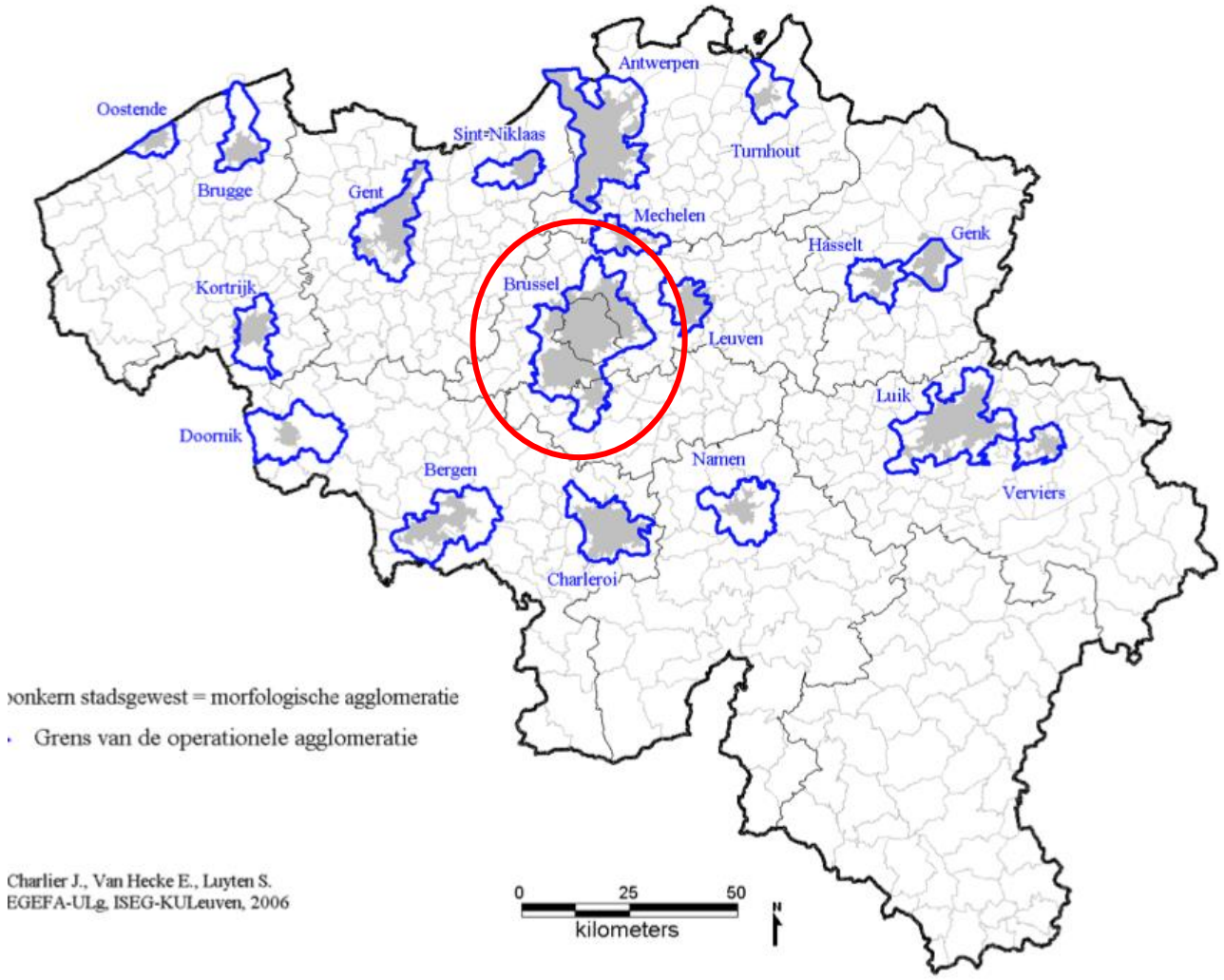
Nieuwenhuijsen, 2017.

- Few studies have explored the association between UGS and diabetes-related mortality

Richardson, 2012; Xu, 2017; James, 2016; Crouse, 2017.

Study setting

- Brussels Agglomeration: ≃ 1.4 million inhabitants; 573 km^2.
- Functional unit in terms of living, working, trade, education, trade, cultural experience and leisure; regardless of administrative boundaries.



Luyten, S., Van Hecke, E. (2001). Working Paper “The Belgian City Regions”. STATBEL: Brussels.

Objectives

- To assess the relationship between exposure to residential green spaces and diabetes-related mortality in the Brussels agglomeration (Belgium).

- To examine potential effect modification by sociodemographic and socioeconomic characteristics in this association.

METHODOLOGY

Data design

2001 Belgian Census

Detailed demographic and socio-economic information of the total population officially residing in Belgium

National Mortality Database: Register data on **migration and mortality** for the follow-up period 01 October 2001 – 31 December 2014 (13.25-year follow-up)

Data design

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Health outcomes

- **Diabetes-related mortality:** ICD-10 codes E10-E14.
  1. Diabetes as the **original** cause of death.
  2. Diabetes as *any* cause of death (**immediate, intermediate, original or additional**).

Data design

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Link to residential address

Residential living environment

Data design

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Link to residential address

Residential living environment

Exposure to residential urban green spaces (UGS)

1. **Surrounding greenness**: Normalised Difference Vegetation Index (NDVI) within a 300m buffer (30m x 30m resolution); Landsat 5.

Data design

2001 Belgian Census

Detailed demographic and socio-economic information of the total population officially residing in Belgium

National Mortality Database: Register data on **migration and mortality** for the follow-up period 01 October 2001 – 31 December 2014 (13.25-year follow-up)

Link to residential address

Residential living environment

Exposure to residential urban green spaces (UGS)

1. **Surrounding greenness**: Normalised Difference Vegetation Index (NDVI) within a 300m buffer (30m x 30m resolution); Landsat 5.
2. **Perceived neighbourhood greenness:** % of households in the statistical ward reporting very good provision of green spaces in their neighbourhood.

Covariates

SOCIODEMOGRAPHIC CHARACTERISTICS

- **Age**
- **Gender**
- **Household Living Arrangement:** Single; Cohabiting.
- **Migrant Background:** Belgian; Other High-Income Country (HIC); Low and Middle-Income Country (LMIC).

(INDIVIDUAL) SOCIOECONOMIC POSITION

- **(Highest) Educational Level:** Tertiary; Higher Secondary; Lower Secondary; Primary/No Formal Education.
- **Housing Tenure:** Owner; Tenant.

(NEIGHBOURHOOD) SOCIOECONOMIC POSITION

- **Percentage of Unemployment** in the Statistical Ward Among the Total Active Working Population.

Statistical analyses

FIRST OBJECTIVE: **Association** between the two indicators of exposure to **residential UGS** (surrounding and perceived neighbourhood greenness) and each outcome of **diabetes-related mortality** (both diabetes as the original cause of death and diabetes as *any* cause of death)

- **Cox proportional hazards models** using **age** as the underlying time scale.
  - Hazard Ratios (HR) and 95% Confidence Intervals (95%CI)
  - Models adjusted by gender, migrant background, educational level, housing tenure, household living arrangement, $PM_{2.5}$ and neighbourhood SEP
  - Confounders included by **stepwise entry**

SECOND OBJECTIVE: Effect modification by **demographic and socioeconomic** characteristics

- **Effect modification analyses**
  - Interaction terms (UGS ## demographic and socioeconomic characteristics) and stratification

RESULTS

Results

Table 1. Baseline characteristics of the study population and mortality and migration during follow-up (2001-2014).

	Women (N = 253,533)		Men (N = 220,832)	
Mean Age at Baseline, mean (SD)	56.1	(11.1)	57.2	(11.5)
Diabetes as the Original Cause of Death, N (%)	684	(0.3)	661	(0.3)
Diabetes as Any Cause of Death, N (%)	2,442	(1.0)	2,899	(1.3)
Emigrations, N (%)	11,161	(4.4)	13,065	(5.9)
Migrant Background, N (%)				
Belgian	191,294	(75.5)	160,906	(72.9)
Other HIC	38,220	(15.1)	34,147	(15.5)
LMIC	24,019	(9.5)	25,779	(11.7)
Educational Level, N (%)				
Tertiary	67,692	(26.7)	73,842	(33.4)
Higher Secondary	57,545	(22.7)	46,226	(20.9)
Lower Secondary	63,810	(25.2)	50,725	(23.0)
Primary/No education	64,486	(25.4)	50,039	(22.7)
Housing Tenure, N (%)				
Owner	168,059	(66.3)	147,311	(66.7)
Tenant	85,474	(33.7)	73,521	(33.3)
Household Living Arrangement, N (%)				
Single	67,296	(26.5)	45,638	(20.7)
Cohabiting	153,658	(60.6)	164,698	(74.6)
Other	32,579	(12.9)	10,496	(4.8)

- Study population of **474,365** individuals between 40 and 80 years old and officially residing in the Brussels agglomeration in 2001.

Results

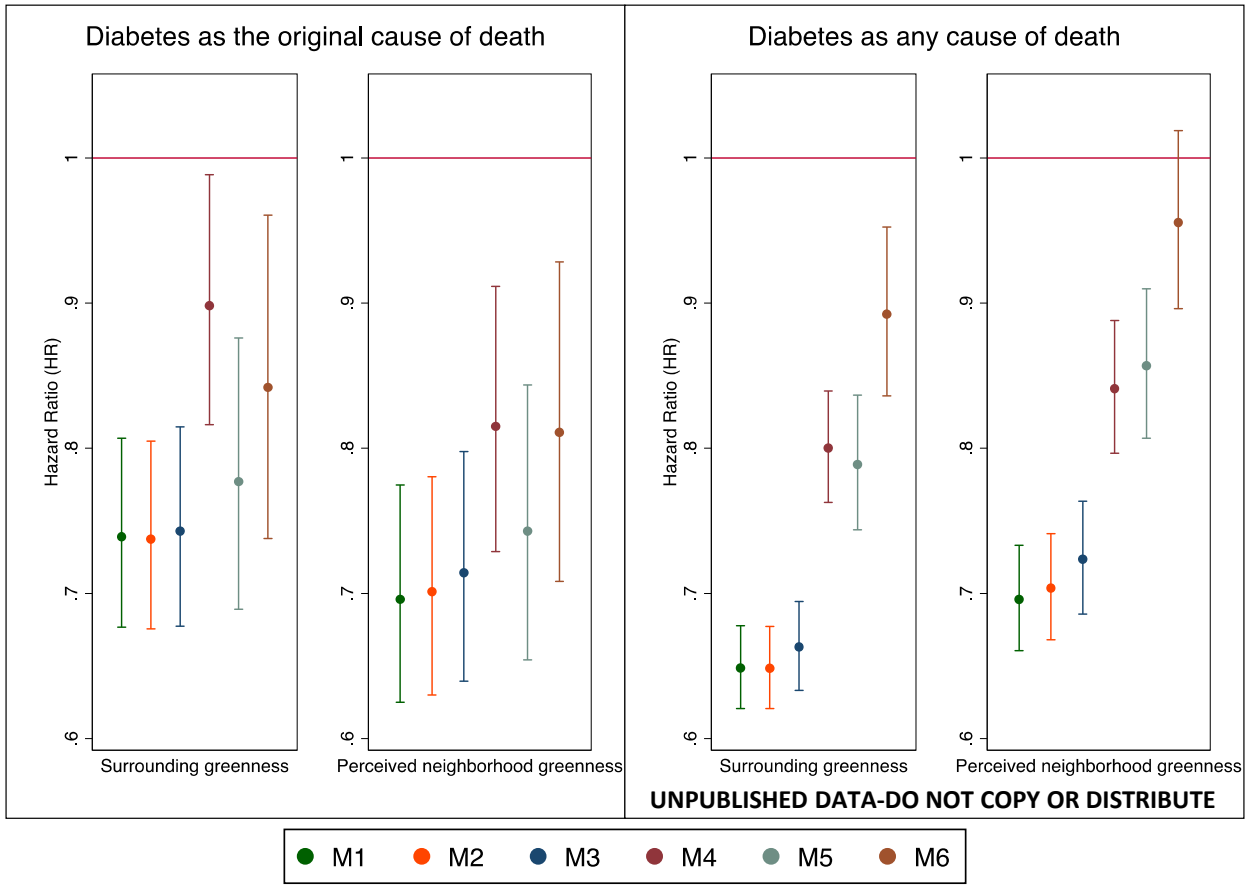
Table 2. Median, interquartile range (IQR), and correlation matrix between indicators of the residential living environment and area-level SEP. Brussels agglomeration, 2001-2014.

	Surrounding greenness (NDVI within a 300m buffer)	**Perceived neighbourhood greenness**	**$PM_{2.5}$ [µg/m3]**	**% Unemployment in the statistical ward**
Median (IQR)	0.5 (0.4 - 0.6)	27.5 (11.5 - 40.8)	18.9 (18.2 - 19.5)	13.0 (9.4 - 19.2)
Surrounding greenness (NDVI within a 300m buffer)	1.000			
Perceived neighbourhood greenness	0.7952*	1.000		
$PM_{2.5}$ [µg/m3]	-0.6498*	-0.4998*	1.000	
% Unemployment in the statistical ward	-0.6758*	-0.5507*	0.4688*	1.000

* $p < 0.001$

Results

Figure 1. Stepwise adjustment of the associations (HR) and confidence intervals (95%CI) between IQR increments of surrounding and perceived neighborhood greenness and diabetes-related mortality (both as the original cause of death and as any cause of death). Brussels agglomeration, 2001-2014.



M1: crude model
(age as the underlying time scale)
M2: M1 + gender
M3: M2 + migrant background
M4: M3 + educational level + housing tenure + household living arrangement
M5: M4 + $PM_{2.5}$
M6: M5 + neighbourhood SEP

Note: Cox proportional hazards models using age as the underlying time scale, follow-up period 1st October 2001 – 31st December 2014.
Surrounding greenness IQR: 0.2; Perceived neighbourhood greenness IQR: 29.3.

Results

INTERACTION TERMS between each residential UGS indicator and **gender, migrant background, educational level and neighbourhood SEP** were included in each fully adjusted model for both diabetes-related mortality outcomes.

- No significant interaction with migrant background and educational level was found.

❑ Diabetes as the original cause of death

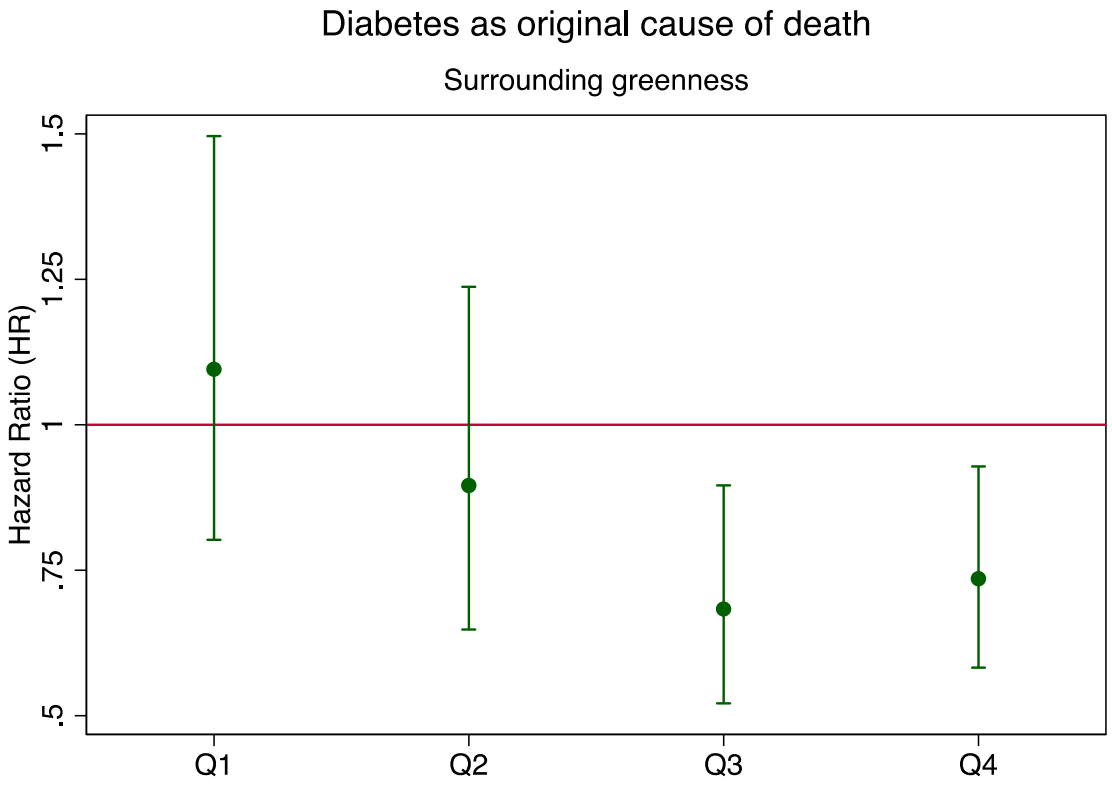
- **Surrounding greenness:** Significant interaction with neighbourhood SEP.
- **Perceived neighbourhood greenness:** Significant interaction with gender.

❑ Diabetes as any cause of death

- **Surrounding greenness and perceived neighbourhood greenness:** Significant interaction with gender.

Results

Figure 2. Associations (HR) and confidence intervals (95%CI) of the association between IQR increments of **surrounding greenness** and **diabetes as the original cause of death**, **by quartiles of neighbourhood SEP** (% of unemployment in the statistical area). Brussels agglomeration, 2001-2014.

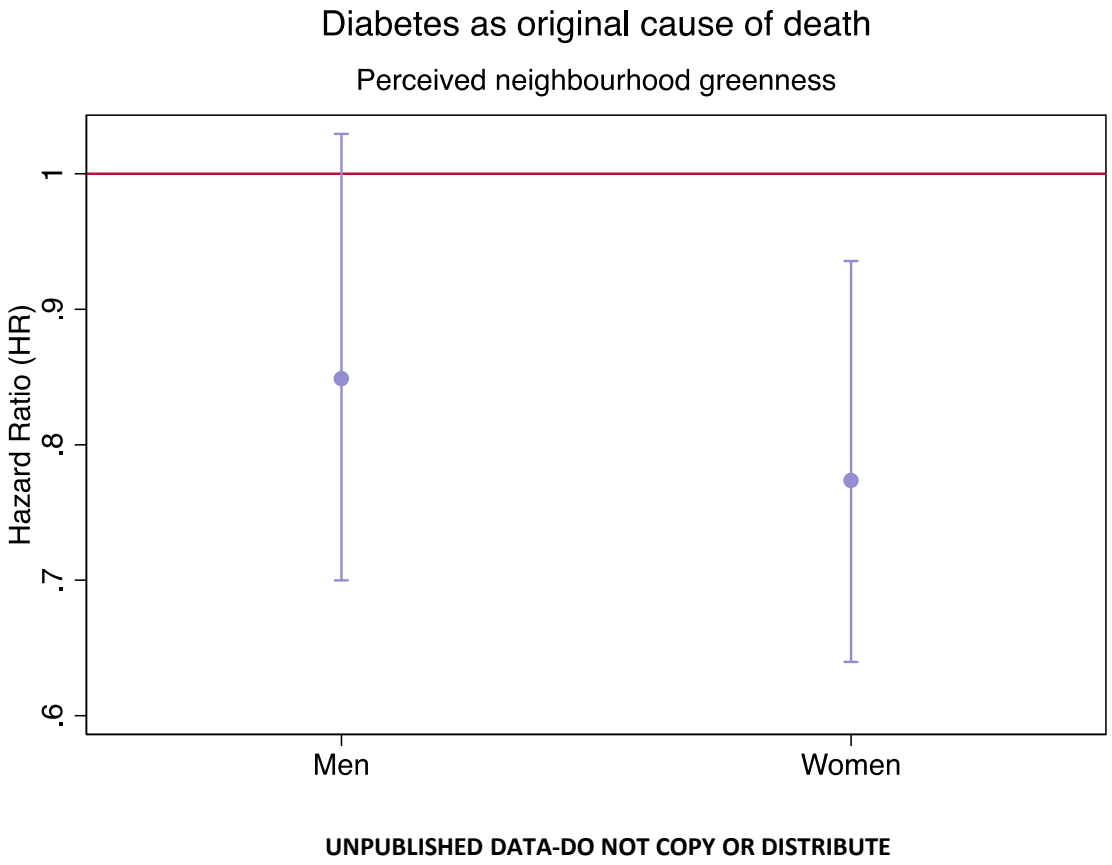


p-value for interaction: 0.0347

Note: Cox proportional hazards models using age as the underlying time scale, follow-up period 1st October 2001 – 31st December 2014. Model adjusted by gender, migrant background, educational level, housing tenure, household living arrangement and $PM_{2.5}$.
Surrounding greenness IQR: 0.2.
Quartiles of neighbourhood SEP (% of unemployment in the statistical ward): Q1 (1.4%-9.4%); Q2 (9.4%-13%); Q3 (13%-19.2%); Q4 (19.3%-56.3%).

Results

Figure 3. Associations (HR) and confidence intervals (95%CI) of the association between IQR increments of **perceived neighbourhood greenness** and **diabetes as the original cause of death**, **by gender**. Brussels agglomeration, 2001-2014.

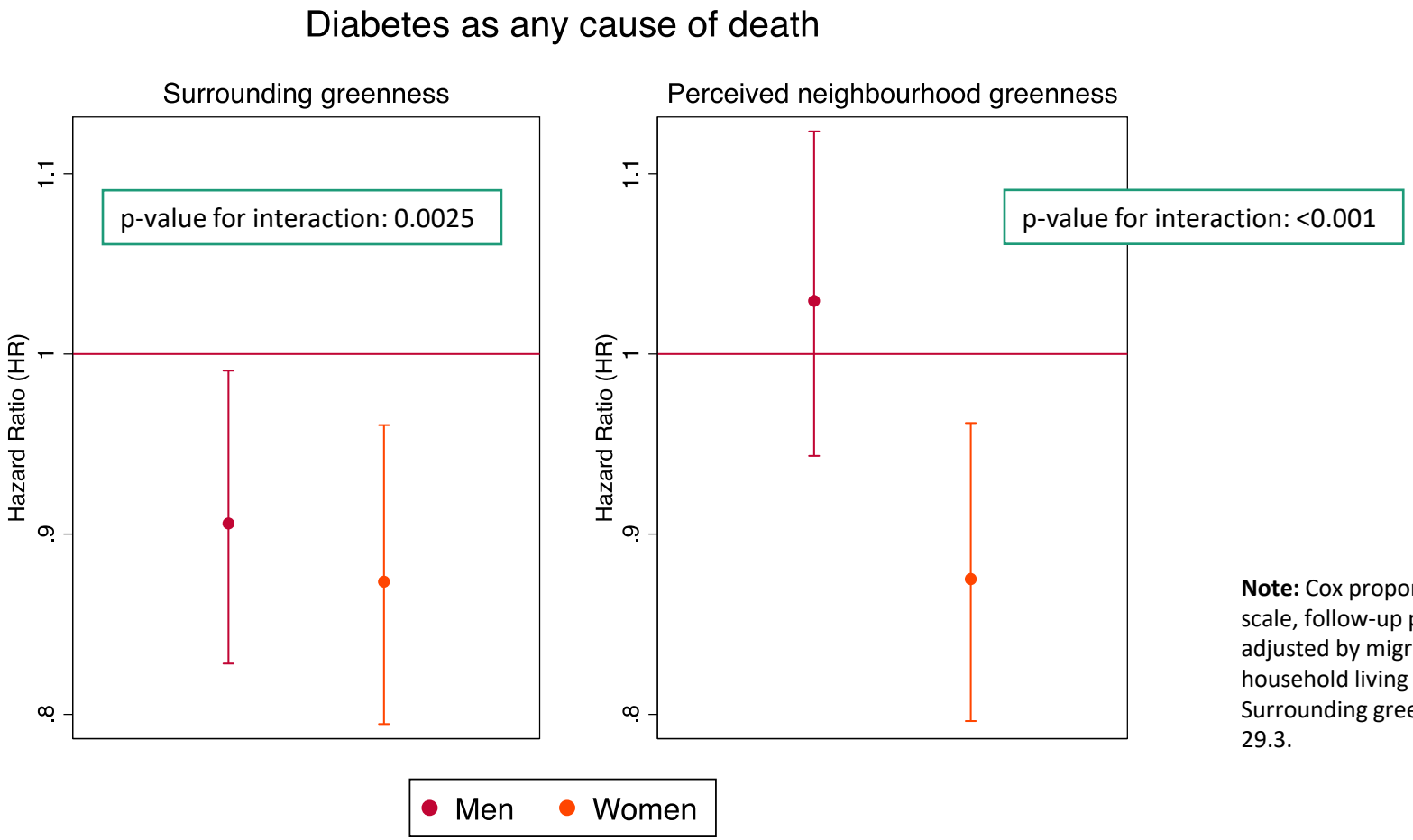


p-value for interaction: 0.0248

Note: Cox proportional hazards models using age as the underlying time scale, follow-up period 1st October 2001 – 31st December 2014. Model adjusted by migrant background, educational level, housing tenure, household living arrangement and $PM_{2.5}$ and neighbourhood SEP.
Perceived neighbourhood greenness IQR: 29.3.

Results

Figure 4. Associations (HR) and confidence intervals (95%CI) of the association between IQR increments of **surrounding and perceived neighbourhood greenness** and **diabetes as any cause of death**, **by gender**. Brussels agglomeration, 2001-2014.



Note: Cox proportional hazards models using age as the underlying time scale, follow-up period 1st October 2001 – 31st December 2014. Model adjusted by migrant background, educational level, housing tenure, household living arrangement and $PM_{2.5}$ and neighbourhood SEP. Surrounding greenness IQR: 0.2; Perceived neighbourhood greenness IQR: 29.3.

Limitations

- **Unable to control for lifestyle factors**
- **No time-varying information on covariates available**
- **Residential address at baseline**
- **Exposure misclassification (only based on residential address)**
- **No information on quality of green spaces**

Strengths

- **Large register dataset**
- **High resolution living environment indicators**
- **Individual exposure**
- **Subjective indicator of residential urban green space**
- **Long follow-up (13.25 years)**

CONCLUSIONS

Conclusions

- **Living near greener spaces** might help **reduce the risk of diabetes-related mortality**.
- Higher levels of **surrounding greenness** near the residence might **especially reduce the risk** of death from diabetes as the original cause in **deprived neighbourhoods**.
- **Perceived neighbourhood greenness** is inversely associated with both indicators of diabetes-related mortality among **women**, but not among men.
- Further research is needed in order to elucidate the mechanisms underlying these associations.

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