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Perception of the Residential Living Environment: The Relationship Between Objective and Subjective Indicators of the Residential Living Environment and Health

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Abstract: Background: Multiple studies have found an association between ambient air quality, noise pollution, green spaces, and health. The underlying mechanisms of this association remain partly unknown. In this study, we focus on subjective perception as a potential underlying factor. **Methods:** The data consisted of a linkage between the 2001 census, register mortality data from the 1st of October 2001 to the 31st of December 2016 and objective indicators of the residential living environment (air and noise pollution and green spaces). We used Cox regression to investigate the impact of objective and subjective indicators of the living environment and their potential interaction effect on all-cause mortality in the Brussels Capital Region. **Results:** A negative subjective perception of the residential living environment is associated with a higher mortality hazard, even when controlling for socio-demographic parameters. Similarly, also objective indicators of air pollutants and green spaces are related to mortality. When studying the interaction effect, the beneficial effect of a neutral subjective perception stands out. Subjectively satisfied individuals living in the worst objective conditions showed the highest mortality hazard. Noise pollution was the only exception, characterised by a lack of an interaction effect. **Conclusion:** This study showed that besides objective indicators, subjective perception of the residential environment also matters and that both interact in influencing life chances. Subjective indicators not only have a genuine independent impact, they also act as an underlying factor in the relationship between objective residential environment and health.

Keywords: mortality; death; environmental health; health inequalities and air pollution

1. Introduction

The link between objective indicators of the living environment and health is well established. Exposure to **ambient air pollution** is amongst others, significantly associated with an increased incidence of lung cancer in adults [1], disrupted lung development in children [2] and an increased incidence of premature births [3]. **Noise pollution** has been associated with an increased risk of cardiovascular diseases [4], increased incidence of diabetes [5] and an increased prevalence of isolated systolic hypertension [6]. In contrast, no significant association between long-term exposure to noise pollution and all-cause mortality was found [7]. For green spaces, there is accumulating evidence for a salutogenic effect on self-assessed health [8], a correlation with a lower mortality [9,10] and a beneficial effect on people with chronic heart failure [11].

The mechanisms underlying these associations are complex and partly unknown. According to the literature, subjective perception of the living environment might be crucial to understand the health effects of the living environment. This is shown by theories such as the stress reduction theory and attention restoration theory [12]. Lachowycz et al. (2013) found that the subjective perception of green spaces may modify the observed effect of green spaces on health outcomes [13]. Similarly,

Babisch et al. (2013) found that the association between objective noise measurement (near airports) and hypertension was stronger for people who reported being more subjectively annoyed by aircraft noise pollution [14]. The influence of subjective perception could also be interpreted through Lazarus' (1984) transactional model of coping and stress [15]. Lercher (1996), who further discussed this model, stated that perception or appraisal is a process through which a person evaluates an exposure. If an individual is aware of a stressful exposure this might lead to the adaptation of cognitive, behavioural, and emotional coping mechanisms [16]. A recent study in Kenya for instance found that the mere participation in air quality studies led residents to develop strategies to cope with air pollution in their neighbourhood [17].

Our study will further address this gap in literature, using the Brussels Capital Region (BCR) as a case study. BCR is the largest metropolitan area in Belgium, with clear divisions in environmental exposures and socio-economic variables. The aim of this paper is twofold: i) assess the association between the objective and the subjective perception of the residential (outdoor) living environment (i.e., air and noise pollution and green spaces) and all-cause mortality; and ii) examine if subjective perception modifies the relationship between objective indicators of the living environment and all-cause mortality.

2. Methodology

Data consist of a linkage between the Belgian 2001 census – including detailed information on socio-economic and demographic characteristics and subjective indicators of the residential living environment – and register data on mortality (and emigration) for the follow-up period 1st October 2001 until 31st December 2016. The data was further linked to objective residential environmental indicators using the residential address of each individual at baseline. We included all persons aged 25-79 officially residing in the Brussels Capital Region at baseline (1st October 2001).

Our study focuses on three environmental dimensions: ambient air pollution, noise pollution and green spaces. The objective indicators included estimates of air and noise pollution levels and a green density metric derived from satellite images. Ambient air pollution was measured using the 2005 average annual concentrations ($\mu g/m^3$) of nitrogen dioxide (NO_2) and particulate matter with an aerodynamic diameter of less than 2.5μm ($PM_{2.5}$) (B*elgian Interregional Environment Agency* (IRCEL), https://www.irceline.be/nl). Noise pollution was operationalised by combining noise levels from air, road, and railway traffic into one indicator expressed as the 24-hour average [day-evening-night (L_{den})] noise level in decibels (dB) (Environment.Brussels, https://environment.brussels/). Surrounding greenness was assessed using the Normalised Difference Vegetation Index (NDVI). The NDVI ranges from 0 to 1, with values closer to 1 indicating greater green density [18]. A more in-depth description of these indicators is available in the study by Rodriguez-Loureiro et al[19].

NO_2 concentrations (threshold of 40$\mu g/m^3$) and noise pollution (53dB L_{den} threshold) were dichotomised according to the WHO threshold (below/above WHO threshold). For $PM_{2,5}$ concentrations we used quintiles since all values exceeded the 10$\mu g/m^3$ annual average WHO-threshold in Belgium. Surrounding greenness was also categorised using quintiles as WHO does not define any thresholds for this variable.

The **subjective perception of the living environment** was derived from the 2001 Belgian census. For each household, respondents were asked to indicate how they perceived the air quality, noise pollution and surrounding greenness in their neighbourhood on a 3-points Likert scale (satisfied, neutral and not satisfied).

To investigate potential **interaction effects** between subjective and objective indicators of the living environment on all-cause mortality, we cross-classified both variables. Our reference category consisted of the combination of a satisfied subjective perception with the lowest concentration of air pollutants, the lowest amount of noise pollution and the highest amount of surrounding greenness. All categories contained more than 1,0% of the cases.

We included gender, age, migration background (Belgian and non-Belgian), household living arrangement (couple, single, other), highest educational level (tertiary, secondary, primary) and

housing tenure (owners, tenants, other) as control variables. The dependent variable consisted of all-cause mortality during the 15-year follow-up period.

We used Cox proportional hazards regression models to investigate the association between each dimension of the outdoor living environment and all-cause mortality. Similarly, to Bauwelinck et al. (2021), we used age as an underlying time scale. Observations were censored when emigration or end of follow-up occurred. To account for differential baseline hazards by age groups, we included a strata term with a 10-year categorization (e.g., from [25-30[, [30, 40[until [70, 79].

First, we assessed the association between each objective indicator (one at a time) and all-cause mortality. Second, we assessed the association between each subjective indicator (one at a time) and all-cause mortality. Finally, we used the combined indicator (objective + subjective) for each environmental dimension to assess the association with all-cause mortality. For each model, we specified a basic model M1 (including the exposure indicator and gender) and a fully adjusted model M2 (additionally adjusting for educational level, housing tenure, migrant background and household living arrangement).

3. Results

Table 1 contains a detailed description of the study population at baseline (2001), all-cause mortality during follow-up, and the objective and subjective indicators of the living environment. After excluding individuals with missing values (24,8%) on covariates, our study population consisted of 464,611 individuals aged 25-79 officially residing in the BCR at baseline (2001). During follow-up (2001-2016), 66,832 individuals died and 40,617 emigrated. The study population consisted mostly of women (52.3%), individuals with secondary education (43.4%), originating from Belgium (59.4%) and living with a partner (61.5%).

Table 1. Socio-demographic characteristics of the population at baseline (2001), objective and subjective characteristics of the residential living environment and all-cause mortality (2001-2016).

Socio-demographic variable	Frequency	Percentage
Gender		
Female	242,953	52.3%
Male	221,658	47,7%
Deaths from all causes during follow-up period 2001-2016, n (%)		
Died	66,832	14.4%
Emigration during follow-up period 2001-2016, n (%)		
Emigrated	40,617	8.7%
Highest educational attainment		
Higher education	173,778	37.4%
Secondary education	201,536	43.4%
Primary education or less	89,297	19.2%
Housing tenure		
Owner	224,712	48.4%
Tenant	227,115	48.9%
Other	12,784	2.8%
Household living arrangement		
Couple	285,719	61.5%
Single	172,234	37.1%
Other	6,658	1.4%
Migration background		
Other	188,743	40.6%
Belgium	275,868	59.4%
Subjective perception variables	**Frequency**	**Percentage**
Air quality		
Not pleasant	136,596	29.4%
Satisfactory	266,953	57.5%
Very pleasant	61,062	13.1%

Noise pollution		
Not pleasant	164,525	35.4%
Satisfactory	224,699	48.4%
Very pleasant	75,387	16.2%
Green spaces		
Poorly equipped	113,030	24.3%
Normally equipped	191,770	41.3%
Very well equipped	159,811	34.4%
Objective variables	**Median**	**Q1-Q3**
PM$_{2.5}$ (µg/m³) annual average concentration, median (IQR)	19.27	18.95 – 19.70
NO$_2$ (µg/m³) annual average concentration, median (IQR)	38.94	35.45 – 41.72
Daily average noise levels, multiple sources, L$_{den}$ (dB)	49.87	47.05 – 52.92
Surrounding greenness: NDVI 300m	0.43	0.34 – 0.53

Source: Belgian 2001 census linked to the mortality register (follow-up 1st October 2001 – 31st December 2016) and environmental exposure data.

The median exposure to average annual concentrations of air pollutants was 19.27 µg/m³ (IQR: 0.85) for PM$_{2.5}$ and 38.94 µg/m³ (IQR: 6.27) for NO$_2$; the daily average exposure to multiple sources of noise pollution was 49.87 dB (IQR: 5.87); residential surrounding greenness within a 300-m buffer was 0.43 (IQR: 0.19).

Overall, individuals seemed to be mostly satisfied with the air and noise pollution levels and with green spaces' provision in their neighbourhood. Respondents reported more frequently unpleasant levels of noise pollution (35.4%) than of air quality (29.4%) and having poorly equipped green spaces in their neighbourhood (24.3%).

Table 2 shows the results for the associations between the **objective indicators** and all-cause mortality. In the basic model, all indicators generate HRs in the expected direction with lower levels of air and noise pollution and a higher density of surrounding greenness being associated with lower mortality. Controlling for socio-demographic variables (M2) attenuated the effects, but associations remained significant (e.g., the quintile with the highest PM$_{2.5}$ concentrations still has an increased mortality hazard of 16% compared with the reference category), except for noise pollution. For surrounding greenness within 300-m of residence, the largest excess mortality was observed for the two quintiles with the lowest residential greenness [1,15% (95%CI: 1.117;1.192) and 1,28% (95%CI: 1.232;1.320)].

Table 2. Hazard ratios (HR) of all-cause mortality and 95% confidence intervals (95% CI) for the objective indicators of the residential living environment, BCR, 2001-2016.

Variable	Description	Frequency (relative)	M1 HR (95%CI)	M2 HR (95%CI)
Air pollution: PM$_{2.5}$ (µg/m³) annual average concentration[1]	Q1 (Least exposed)	92913	1.00 (ref.)	1.00 (ref.)
	Q2	92830	1.12** [1.08;1.15]	1.05** [1.02;1.09]
	Q3	92990	1.20** [1.16;1.23]	1.09** [1.06;1.13]
	Q4	92952	1.23** [1.19;1.27]	1.11** [1.08;1.15]
	Q5 (Most exposed)	92926	1.28** [1.24;1.32]	1.16** 1.12;1.20]
Air pollution: NO$_2$ (µg/m³) annual average concentration	Below WHO guideline (40 µg/m³)	282079	1.00 (ref.)	1.00 (ref.)
	Above WHO guideline	182532	1.16** [1.13;1.18]	1.09** [1.07;1.12]
Noise pollution : Multi sources L$_{den}$ (dB)	Below WHO guideline (53 dB)	350690	1.00 (ref.)	1.00 (ref.)
	Above WHO guideline	113921	1.04** [1.01;1.06]	1.01 [0.99;1.04]
Surrounding greenness: NDVI 300m[2]	Most surrounding greenness (Q1)	92920	1.00 (ref.)	1.00 (ref.)
	Q2	92896	1.09** [1.06;1.12]	1.06** [1.03;1.09]
	Q3	92952	1.12** [1.09;1.15]	1.06** [1.03;1.09]
	Q4	92943	1.27** [1.23;1.31]	1.15** [1.12;1.19]

Least surrounding greenness (Q5)	92900	1.47** [1.42;1.52]	1.28** [1.23;1.32]

[1]PM2.5 annual average concentration *(µg/m³)* quintiles : *Quintile 1 : [Min ;18.74], quintile 2 :]18.74 ;19.10], quintile 3 :]19.10 ;19.42], quintile 4 :]19.42 ;19.82] and quintile 5 :]19.82, Max]*
[2]NDVI 300m surrounding greenness quintiles : Quintile 1 : [Max;0.56[, quintile 2 : [0.56;0.46[, quintile 3 : [0.46;0.39[, quintile 4 : [0.39;0.31[, quintile 5 : [0.31; Min]

*Significance p<0.05. **Significance p<0.01. Results from Cox PH regression models using age as the underlying timescale for the follow-up period 2001-2016. M1 adjusted by gender, M2=M1 + migrant background, educational level, housing tenure and household living arrangement.

Source: Belgian 2001 census linked to the mortality register (follow-up 1st October 2001 – 31st December 2016) and exposure data.

The associations between the **subjective indicators of the living environment** and all-cause mortality are displayed in Table 3. Overall, rating any dimension of the living environment positively or neutral generated lower HR's. After adjustment for covariates, the difference between rating the environment positively or neutrally disappeared [e.g., for green spaces: normally equipped HR 0.91 (95%CI: 0.885, 0.936), very well-equipped HR 0.91 (95%CI: 0.880, 0.933)]. Rating the noise pollution in the neighbourhood as very pleasant was not significantly associated with decreased risk of all-cause mortality.

Table 3. Hazard ratios (HR) of all-cause mortality and 95% confidence intervals (95% CI) for the subjective perception of the residential living environment, BCR, 2001-2016.

Variable	Description	M1 HR (95% CI)	M2 HR (95% CI)
Perception: Air quality	*Very pleasant*	1.00 (ref.)	1.00 (ref.)
	Satisfactory	1.00 [0.97;1.03]	0.97* [0.94;0.99]
	Not pleasant	1.11** [1.08;1.15]	1.04* [1.01;1.07]
Perception: Noise pollution	*Very pleasant*	1.00 (ref.)	1.00 (ref.)
	Satisfactory	0.99 [0.97;1.02]	0.97* [0.94;1.00]
	Not pleasant	1.08** [1.05;1.11]	1.01 [0.98;1.04]
Perception: Green spaces	*Very well equipped*	1.00 (ref.)	1.00 (ref.)
	Well equipped	1.04** [1.02;1.07]	1.01 [0.98;1.03]
	Poorly equipped	1.20** [1.17;1.24]	1.10** [1.07;1.14]

*Significance p<0.05. **Significance p<0.01. Results from Cox PH regression models using age as the underlying timescale for the follow-up period 2001-2016. M1 adjusted by gender, M2=M1 + migrant background, educational level, housing tenure and household living arrangement.

Source: Belgian 2001 census linked to the mortality register (follow-up 1st October 2001 – 31st December 2016) and exposure data.

Figure 1 presents the potential mediating effect of the subjective perception on the association between the objective residential living environment and mortality (results are fully reported in Table 1, 2 and 3 in the addendum).
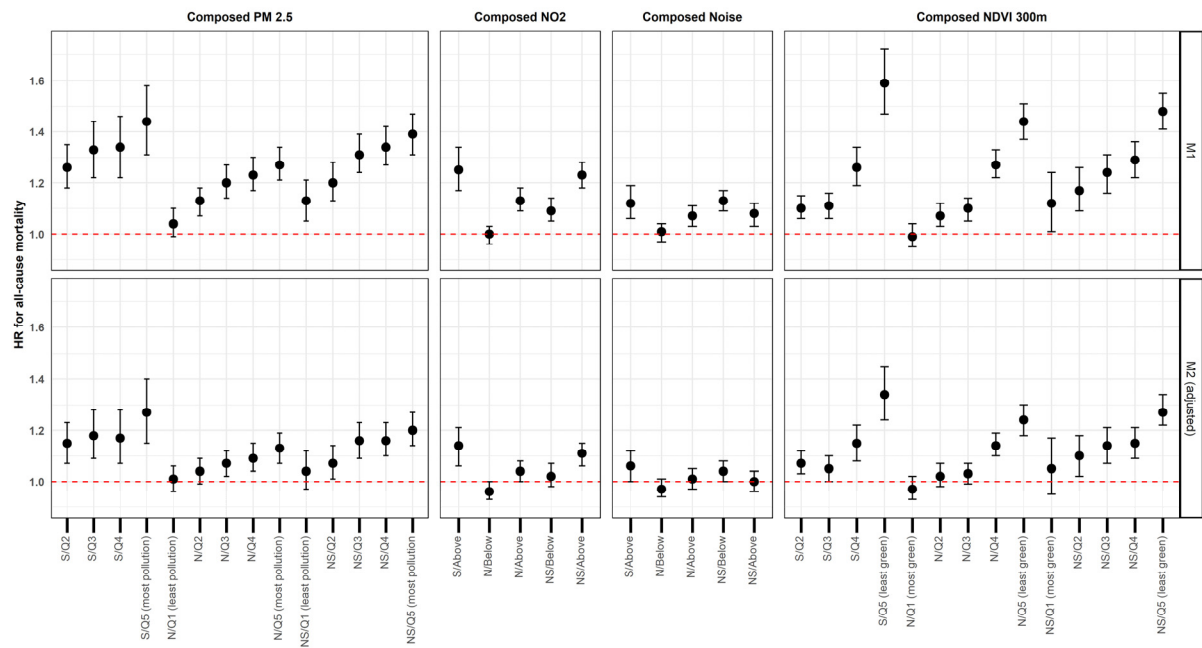
Figure 1. Hazard ratios (HR) of all-cause mortality and 95% confidence intervals (95% CI) for the composed variables of the residential living environment, BCR, 2001-2016.

Abbreviations: Subjective perception: S = Satisfied, N = Neutral and NS = Not satisfied; Objective indicators categorized into quintiles: Q1 = the most "optimal" quintile (i.e., least pollution, most surrounding greenness), … and Q5 = the least "optimal" quintile (i.e., most pollution, least surrounding greenness); Objective indicators categorized based on WHO threshold: Above = value is higher than the threshold value, below = value is lower than the WHO threshold value.

Reference group: For each indicator, the reference group is the most "optimal condition" (I.e., a satisfied perception combined with the least pollution or most green space)

Source: Belgian 2001 census linked to the mortality register (follow-up 1st October 2001 – 31st December 2016) and environmental exposure data.

Overall, three general patterns arise. Unexpectedly, individuals who reported being satisfied with their living environment seemed affected by poorer conditions (more air pollution, more noise pollution or less surrounding greenness). The category combining a satisfied subjective perception with the least optimal objective conditions showed the highest HR (e.g., for surrounding greenness an HR of 1.34 [1.24 -1.45] was observed for this category).

Secondly, we found a positive effect (i.e., a decline in mortality hazard) of being normally satisfied (i.e., the neutral option) with air quality, noise pollution and surrounding greenness. Individuals reporting being "very satisfied" or "not satisfied" differ significantly from the reference category when they live in an area in the second or higher quintile in terms of surrounding greenness (S/Q2: HR 1.07 [1.03;1.12]; NS/Q2: HR 1.10 [1.02;1.18]). However, individuals with a neutral subjective perception living in Q2 (HR 1.02 [0.98; 1.07]) or even Q3 (HR 1.03 [0.99; 1.07] do not have a significantly increased mortality hazard in comparison with the reference category.

Thirdly, there does not seem to be an additive effect of reporting poor environmental quality and being exposed to it. For the non-satisfied categories, the results for the objective indicators and composed indicators are rather similar. E.g., for surrounding greenness, a HR of 1.15 [1.12;1.19] was observed for the 4th quintile. For the non-satisfied group of the composed variable, the HR was the same (HR 1. 15 [1.090;1.210]) for this same quintile.

To strengthen our findings, we conducted several **sensitivity analyses** (See Table 4, 5 and 6 in the addendum). First, we filtered out individuals that moved between 1991 and 2003 and repeated all analyses. The results for this subpopulation were in line with the results observed for the main population.

Secondly, we analysed with the subpopulation that assessed its health as "good" or "very good" in the 2001 census, in order to partially counter the lack of information on individual lifestyle factors (e.g., smoking, physical activity, etc.) that influence all-cause mortality [20]. Analysis for this subpopulation provided unexpected results. The influence of the objective indicators remained unchanged (i.e., more pollution and less surrounding greenness still resulted in a higher mortality hazard), but clear differences were found with respect to the influence of the subjective indicators. In contrast to the main analysis, individuals who were not satisfied with their living environment in terms of noise- and air pollution had significantly lower mortality hazards compared to the reference category (satisfied individuals), which also influenced the results for the composed variables. However, persons with a satisfied perception, residing in the least optimal objective conditions still had the highest mortality hazard.

4. Discussion

The results for the objective indicators align with current literature. Higher concentrations of air pollutants [1,21] and less surrounding greenness [9,10,22,23] were significantly related to higher all-cause mortality hazards [19]. These findings persist when controlling for socio-demographic variables. For noise pollution, we did not find a significant association with all-cause mortality. This result is in line with Tonne et al. (2016). Other studies on noise pollution mainly focus on specific pathologies which we could not verify in our study.

Babisch et al. (2013) found that a negative subjective perception (labelled "annoyance") added to the risk of hypertension due to aircraft noise exposure [6]. This is a finding we could not replicate for all-cause mortality in our study. We found that mortality hazards obtained for the composed variables for individuals with an unsatisfied ("not satisfied") perception of their neighbourhood did not differ substantially from the mortality hazards obtained for the objective indicators. In other words, there seemed to be no effect modification for individuals reporting being not satisfied with the quality of their residential living environment.

However, effect modification was noticeable for individuals with a satisfied or neutral perception. Among satisfied individuals, we observed that residing in the least optimal objective conditions (highest concentration of air pollutants or least surrounding greenness) had the highest mortality hazards. Additionally, we noticed a beneficial influence of a neutral perception. Objective categories with higher relative mortality no longer showed a significantly higher HR when combined with a neutral perception. Both of these findings can be explained via coping mechanisms[15,16] and the transactional model of coping and stress[15]. Satisfied individuals living in a poor objective environment, might not realise that the quality of their residential living environment is lacking. Therefore, they might see no reason to adopt coping mechanisms, which could result in the higher mortality hazards we found.

Individuals with a more neutral perception might, in this sense, be more aware of the objective conditions of their living environment and thus adopt coping strategies. This might explain why the relationship between surrounding greenness and all-cause mortality is strongly modified (and even neutralised in the first three quintiles) for individuals with a neutral subjective perception. Our interpretation is in line with the study by Ngo et al. (2017), who found that participants in a study on air pollution in Kenya were more aware of the relationship between air pollution and their health and thus were more actively looking for coping mechanisms [17].

The question then arises why this effect was not observed among individuals who were not satisfied with the quality of their living environment. One could expect that these individuals would adopt coping mechanisms as well and thus have lower mortality hazards than satisfied individuals. We hypothesize that this might be due to a selection effect. Individuals in poor health might, in general, perceive their neighbourhood more negatively because of being mentally (and physically)

in bad shape. Au et al. (2014) demonstrated that self-assessed health is most strongly associated with vitality (energetic feeling), limiting mobility (physical functioning) and the presence of bodily pain [24]. These health conditions could in turn also influence the likelihood of an individual adopting coping mechanisms.

Further argumentation for the theory of coping mechanisms and the selection effect can be found in the results of the sensitivity analysis. We noticed that, in the healthy subpopulation, individuals with a neutral or even unsatisfied subjective perception had a lower mortality hazard than those with a satisfied perception. This in turn also influenced the results for the composed variables. We can expect that in a healthy subpopulation, subjectively unsatisfied individuals are more capable of developing and exercising coping strategies. Also, by filtering out individuals in poor health, we partially work around the potential selection effect where an individual's health influences the perception of the residential living environment. Both interpretations can help to explain the different results obtained for the healthy subpopulation and the main population.

Strengths, Limitations and (Policy) Recommendations

In the discussion above we hypothesized on the influence of a selection effect, where poor health negatively influences subjective perception. Since we do not dispose of longitudinal data, we could not verify causation between both. We partially worked around this limitation by repeating the analysis for a healthy subpopulation. Another option would be to work with aggregated subjective perception instead of individual perception as demonstrated in other studies [25].

Another limitation is the lack of information on individual lifestyle factors. These factors can influence all-cause mortality [26], but also subjective perception [20] (e.g., someone prone to walking could be more sensitive to the quantity of green spaces in his or her neighbourhood). However, we did control for socioeconomic factors which have been shown to be related to these individual lifestyle factors [27]. Additionally, we performed a sensitivity analysis for a healthy subpopulation to partially circumvent this limitation.

We could not account for individuals moving from their residential address during follow-up (in our sensitivity analysis we focussed on individuals who moved before the 2001 census). Also, we did not study the effect of multiple exposures on mortality. To some extent, we might expect some collinearity between the exposure variables (e.g., between green space provision and air quality). But we did not assess what being exposed to, for example, air- and noise pollution meant in comparison with only being exposed to one of these

A strength of our study is related to our exhaustive dataset combined with a long mortality follow-up period. Additionally, exposure data were linked to the residential address and had a high spatial resolution. Finally, we could include both subjective and objective indicators of the residential living environment in our analysis. Studies of this kind are relatively scarce and, to our knowledge, had not yet been conducted in Belgium.

Our study showcases the importance that individual's subjective perception plays when considering the relationship between the objective parameters of the residential living environment and health. By making individuals more aware of the quality of their living environment, they can develop and exercise coping mechanisms. Public initiatives, backed by policymakers, that directly involve residents in a discussion on the quality of their living environment could therefore have a beneficial effect. In this light, the emergence of more and more examples of public science can also be seen as a positive development.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org. The first three tables in the addendum show the same results as Figure 1 in the main text. However, the precise numerical values are more easily deducible from the tables. The first table in the addendum shows the results (Hazard Ratios and 95% CIs) for the composed variable on air pollution. The second supplementary table shows the results for the composed variable on noise pollution, and the third table in the addendum shows the results for the composed variable on green spaces. Supplementary Tables 4-6 are part of the sensitivity analysis. They show the results for the same indicators (objective indicators, subjective indicators, and composed indicators) under three conditions. The first condition ("Filter 1") is the same as used in the main

text (i.e., individuals aged 25-79, who have no missing values). The second condition ("Filter 2") includes only individuals with self-reported health as either "good" or "very good." The final condition builds on condition one but includes only individuals who did not move between 1993 and 2001.

Ethical approval and consent to participate: Ethical Committee approval for this study is not deemed necessary, since (1) This study was performed within the legal framework of the Belgian Cancer Registry (BCR). Based on the Coordinated Law of 10 May 2015 (art. 138), BCR has a legal task to collect data on cancer, subject it to quality control, process and analyze it, encrypt and store it, report on it, make it accessible for research and protect it; and (2) This retrospective study does not fall under the Belgian Law of 7 May 2004 regarding experiments on human persons (art. 3,§2). The data controller shall be exempt from the obligation to disclose information to the persons whose data are processed where notification to the data subject is impossible or takes disproportionate effort; in particular when data are processed for statistical purposes or for historical or scientific research (cfr. Art. 14.5, b. GDPR EU 2016/67). Additionally, consent prior to publication is unnecessary since only aggregated data and/or results are shown in this manuscript.

Availability of data and materials: Due to privacy concerns, data used for this current study can not be made publicly available.

Competing Interests: There are no competing interests for any author.

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