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Short communication

Neighborhood greenness, but not walkability, is associated with self-rated measures of health in older adults: An analysis of the Canadian Longitudinal Study on Aging

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ABSTRACT

The purpose of this analysis was to determine whether older Canadians residing in neighborhoods characterized by denser greenness or higher walkability have better self-reported health outcomes at 3-year follow-up. Data on self-reported chronic diseases (composite score of 10 conditions) and self-rated measures of health (general health, mental health, and healthy aging) from the Canadian Longitudinal Study on Aging (CLSA) were used as outcomes. The CLSA database was linked with the Canadian Active Living Environments (Can-ALE), a measure of walkability, and Normalized Difference Vegetation Index (NDVI), a measure of greenness. The analytic sample consisted of adults aged 65 and older ($n = 15339$, age 72.9 ± 5.6, 50 % female). Crude and adjusted associations were assessed using Poisson regression and proportional odds regression modelling. The 4th quartile of greenness was associated with the chronic disease index and all three measures of self-rated health (general health, mental health, and healthy aging); living in a neighborhood with the highest greenness was associated with better health three years later when compared to those in the lowest quartile of greenness. After adjustment for covariates of age, sex, income, education, and physical activity levels, only the association for the 3rd quartile of greenness was significantly associated with general health (OR: 0.90, 95 %CI: 0.81–0.99) and mental health (OR: 0.88, 95 %CI: 0.79-0.97). Can-ALE was not associated with any of the outcomes assessed. Future research assessing perceived environmental walkability and geriatric relevant health outcomes rather than chronic disease may provide greater insight into our understanding of age-friendly environments.

1. Introduction

The United Nations declared 2021–2030 the Decade of Healthy Aging, a collaborative effort that aligns with the previously established Sustainable Development Goals (World Health Organization, 2020). One of the areas of focus is age-friendly environments, that is, creating communities that support older adults with being socially and physically active, that provide access to needed services such as healthcare and transportation, and that have a culture of inclusion. Two important aspects of age-friendly environments are the built environment (the human-made space in which people live, work, and play) and the natural environment.

A growing body of research suggests that the built and natural environment of a neighborhood impacts the health and lifestyle of its residents. For example, a recent study found that older adults living in areas characterized by higher greenness and better walkability reported higher levels of physical activity (Klicnik et al., 2022). Similarly, a recent scoping review found that neighborhood walkability and greenness were associated with chronic health conditions such as cardiovascular disease, diabetes, and depression/anxiety in Canadians (McCormack et al., 2019). However, only one study in that review included older adults.

Little is known of the relationship between these important environmental factors and overall health among our aging population. Thus, the purpose of this analysis was to examine whether living in areas characterized by denser greenness or higher walkability is associated

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with better self-reported health outcomes in older Canadians.

2. Materials and methods

2.1. Data Source:

The Canadian Longitudinal Study on Aging (CLSA) is a nationally representative, stratified, random sample of Canadians aged 45–85 years. Baseline data were collected between 2011 and 2015; participants in the Tracking Cohort (n = 21,000; dataset version 3.5 and 2.1) and the Comprehensive Cohort (n = 30,000; dataset version 4.1 and 3.0) completed a questionnaire by telephone. Follow-up data were collected between 2015 and 2018. The purpose of the CLSA is to track individuals through older adulthood at three-year intervals to gain a more comprehensive understanding of the aging process. Full details on participants, sampling strategy, and study protocol have been published in previous work (Raina et al., 2019). The protocol of the CLSA has been reviewed and approved by 13 research ethics boards across Canada. Changes to the CLSA protocol are reviewed annually and written consent is obtained from all participants. The Ontario Tech University Research Ethics Board approved secondary analysis of the dataset (REB # 15934).

Data from the CLSA were linked with data on neighborhood greenness and walkability obtained from the Canadian Urban Environmental Health Research Consortium platform (Brook et al., 2018) using the participant's residential postal code.

2.2. Participants:

Our study sample consisted of a subset of CLSA participants aged 65 and older with follow up data (n = 18,111). After removing participants with incomplete/missing measurements for the outcome (n = 1,137) and exposure variables (n = 406), and participants whose postal code changed at follow up (n = 1,229), the final analytic sample was 15,339 (See Supplementary Table 1 for sample comparison).

3. Outcome variables

3.1. Chronic conditions (follow up):

As recommended by Diederichs et al. (2011), we used ten measures (chronic diseases and risk factors) for assessment. For each condition, participants were asked ***at follow-up*** if a doctor had ever told them that they have the condition. Conditions included were: 1) osteoarthritis (hand, hip, or knee), 2) chronic obstructive pulmonary disease (emphysema, chronic bronchitis, chronic obstructive pulmonary disease, or chronic changes due to smoking), 3) heart disease (including congestive heart failure), 4) angina (angina or chest pain due to heart disease), 5) myocardial infarction, 6) diabetes (diabetes, borderline diabetes, or high blood sugar), 7) stroke, 8) mood disorder (depression, bipolar, mania, or dysthymia), 9) cancer (any type), or 10) hypertension. The *yes* responses were tallied to determine a composite chronic condition score between 0 and 10.

Self-Rated Health (follow up): We used three self-rated health variables that assess different dimensions of health. For self-rated *healthy aging*, participants were asked “In terms of your own healthy aging, would you say it is excellent, very good, good, fair, or poor”? Similar questions were asked for self-rated *general health*, and self-rated *mental health*. Response options were coded from 1 (excellent) to 5 (poor). Due to small sample sizes, categories 4 (fair) and 5 (poor) were collapsed.

3.2. Exposure variables

Canadian Active Living Environment (Can-ALE): This is a composite index characterizing the favorability of the active living environments (or “***walkability***”) of neighborhoods (Brook et al., 2018). The Can-ALE index includes intersection density, dwelling density, and points of interest (Ross et al., 2018), calculated as z-scores. The index is measured on a scale of 1–5, indicating very low, low, moderate, high, and very high Can-ALE, respectively. A higher Can-ALE indicates a more favorable active living environment. The Can-ALE measures for 2016 were derived from 1 km circular buffers based on Statistics Canada dissemination areas. A cluster analysis (k-medians approach) was performed to assign each dissemination area to one of the 5 levels described above (Ross et al., 2018). Can-ALE levels of 4 (high) and 5 (very high) were collapsed due to small sample sizes.

Normalized Difference Vegetation Index (NDVI): This is a widely used indicator of the quantity of green vegetation on the ground, which is derived from satellite imagery (Crouse et al., 2017). The mean of annual mean NDVI values within 500 m from residential postal codes of participants was used to evaluate greenness exposure. Buffers between 500 and 999 m have been most frequently used when examining environment and physical health (Browning and Lee, 2017). Annual mean NDVI values were assigned to participants based on year of recruitment. Since NDVI data for 2012 were not available, the average of 2011 and 2013 values was assigned to participants recruited in 2012. Negative values indicate areas of water, values around 0 indicate barren or sparsely vegetated areas, and values closer to 1 indicate dense vegetation. NDVI values linked to the CLSA dataset were divided into quartiles (0.001–0.338, 0.339–0.415, 0.416–0.494, and 0.495–0.743), with the higher quartiles indicative of more dense vegetation, or ***greenness***.

Covariates: Self-reported age, sex, income, education, and baseline physical activity collected via questionnaire were included as covariates. For *education,* participants were classified as: less than secondary school graduation, secondary school graduation / no post-secondary education, some post-secondary education, or post-secondary degree/ diploma. For *total household income*, participants reported income in categories of: < $20,000, $20,000 to <$50,000, $50,000 to <$100,000, $100,000 to <$150,000, or > $150,000. For *total physical activity*, responses to 5 questions from the Physical Activity Scale for the Elderly were combined to calculate hours per week of light, moderate, and strenuous physical activity, walking, and exercise (Washburn et al., 1993).

Statistical analysis: All analyses were performed using the R statistical package (v4.2) (R Core Team, 2022). Percentages were used to describe the distribution of the categorical variables at baseline, while means and standard deviations were used for continuous variables. An exponentiated Poisson regression was used to assess the association between NDVI and the Can-ALE index with the chronic condition outcome, while proportional odds logistic regression modelling was used to determine odds for the self-rated health outcomes.

Statistical significance was determined using 95 % confidence intervals and p-values < 0.05. To ensure national representation and to compensate for underrepresented groups, sampling weights provided by the CLSA (Raina et al., 2019) were applied to all models.

4. Results

Table 1 presents demographic data by sex. The mean age for the sample was 72.9 ± 5.6, and 50.1 % were female.

Table 2 presents crude and adjusted associations for the main analyses. For Can-ALE, there were no significant crude or adjusted associations with the exception of level 2 of the Can-ALE and chronic conditions (OR: 0.96, 95 %CI: 0.93–1.00). For greenness, the crude models consistently showed an association between the 4th quartile of greenness and fewer chronic conditions, as well as better self-rated health compared to those in the first quartile. In adjusted models, only the association between living in a neighborhood in the 3rd quartile was associated with better general health (OR: 0.90, 95 %CI: 0.81–0.99) and mental health (OR: 0.88, 95 %CI: 0.79–0.97), compared to those in the first quartile.

Table 1
Sample characteristics by sex.

		Females (n = 7689)	Males (n = 7650)	Total (n = 15339)
Age (mean (SD))		72.9 (5.7)	72.9 (5.6)	72.9 (5.6)
Walkability (Can-ALE) level (%)	1 - Very Low	27.4	29.3	28.3
	2	32.0	34.3	33.2
	3	28.7	26.1	27.4
	4/5 - High/Very High	11.9	10.2	11.1
Greenness (NDVI) quartile (%)*	1st	27.9	24.2	26.0
	2nd	25.9	24.0	25.0
	3rd	24.2	25.6	24.9
	4th	21.9	26.3	24.1
Number of Chronic Conditions, mean (SD)		2.0 (1.4)	2.1 (1.5)	2.1 (1.5)
Self-Rated Healthy Aging (%)	1 - Excellent	18.2	19.1	18.7
	2 - Very Good	44.4	42.4	43.4
	3 - Good	29.5	30.2	29.8
	4 – Fair/Poor	7.9	8.3	8.1
Self-Rated General Health (%)	1 - Excellent	16.2	17.2	16.7
	2 - Very Good	40.3	39.7	40.0
	3 - Good	30.8	30.1	30.5
	4 – Fair/Poor	12.6	12.9	12.8
Self-Rated Mental Health (%)*	1 - Excellent	23.4	28.0	25.7
	2 - Very Good	43.2	40.4	41.8
	3 - Good	28.2	26.9	27.6
	4 – Fair/Poor	5.2	4.7	5.0
Total Physical Activity Hours (all intensities) per week, mean (SD)*		6.8 (6.8)	8.4 (8.1)	7.6 (7.5)
Total Household Income, (%)*	1 - < $20,000	10.1	3.6	6.7
	2 - $20,000 to <$50,000	43.9	28.1	35.7
	3 - $50,000 to <$100,000	34.6	44.3	39.6
	4 - $100,000 to <$150,000	8.0	15.3	11.8
	5 - > $150,000	3.4	8.7	6.2
Education Level, (%)	1 - < Secondary school graduation	11.1	8.7	9.9
	2 - Secondary school graduation, no post-secondary education	13.5	9.9	11.7
	3 - Some post-secondary education	8.3	7.6	7.9
	4 - Post-secondary degree/diploma	67.1	73.8	70.5

*Variables are significantly different by sex.

Table 2
Crude and adjusted associations of self-reported chronic conditions and self-rated measures of health with walkability and greenness.

		Chronic Conditions	Healthy Aging	General Health	Mental Health
a) Walkability (Can-ALE)					
Crude	1	Referent			
	2	0.96 (0.93, 1.00)*	0.96 (0.88, 1.04)	1.00 (0.92, 1.09)	0.94 (0.86, 1.02)
	3	1.02 (0.99–1.06)	1.04 (0.95, 1.14)	1.06 (0.97, 1.16)	1.01 (0.92, 1.11)
	4/5	0.96 (0.92–1.01)	1.05 (0.93, 1.19)	1.01 (0.90, 1.14)	0.89 (0.79, 1.01)
Adjusted	1	Referent			
	2	0.97 (0.94, 1.01)	0.98 (0.89, 1.07)	1.00 (0.92, 1.10)	0.97 (0.89, 1.07)
	3	1.02 (0.98, 1.05)	1.05 (0.95, 1.15)	1.06 (0.97, 1.17)	1.02 (0.93, 1.12)
	4/5	0.98 (0.93, 1.03)	1.10 (0.96, 1.25)	1.06 (0.93, 1.20)	0.94 (0.82, 1.06)
b) Greenness (NDVI)					
Crude	1	Referent			
	2	0.99 (0.96, 1.03)	0.95 (0.86, 1.05)	0.92 (0.84, 1.02)	1.00 (0.91, 1.10)
	3	0.97 (0.94, 1.01)	0.91 (0.83, 1.01)	0.87 (0.79, 0.96)*	0.85 (0.77, 0.93)*
	4	0.95 (0.92, 0.99)*	0.88 (0.81, 0.97)*	0.88 (0.80, 0.97)*	0.89 (0.80, 0.97)*
Adjusted	1	Referent			
	2	0.99 (0.95, 1.03)	0.98 (0.88, 1.08)	0.95 (0.85, 1.05)	1.03 (0.93, 1.14)
	3	0.99 (0.95, 1.03)	0.94 (0.85, 1.04)	0.90 (0.81, 0.99)*	0.88 (0.79, 0.97)*
	4	0.97 (0.94, 1.01)	0.92 (0.83, 1.02)	0.93 (0.84, 1.03)	0.95 (0.85, 1.05)

adjusted for age, sex, income, education, and physical activity levels.

5. Discussion

We sought to determine whether greenness and walkability were associated with self-reported chronic conditions and self-rated health in older Canadians. Our primary finding is that living in a neighborhood with denser greenness (NDVI) may positively impact measures of self-rated healthy aging, general health, and mental health. On the contrary, walkability (Can-ALE) was not associated with any of the measures assessed.

Living in neighborhoods with denser greenness was associated with better self-rated health. This is in line with previous research that consistently shows an association of greenness with mental health, general health, and healthy aging (Cottagiri et al., 2022; Fong et al., 2018; Orban et al., 2017; Zhu et al., 2019). Of note, while greenness was associated with the chronic disease index in crude models, it was no longer significant after adjustment for covariates. This is contrary to findings from Brown et al., who found that in a cross-sectional analysis of a sample of adults in the USA aged 65 years and older, higher greenness was associated with decreased risk of hypertension, hyperlipidemia, and diabetes (Brown et al., 2016). However, as noted by Fong et al., there are inconsistencies when looking at the association between greenness and chronic disease outcomes (Fong et al., 2018). For example, in some countries and for some chronic conditions, greenness may be important (Fan et al., 2020), while for others, perhaps there is a more distal association. In Canada, although greenness has declined in urban areas, there are still many urban centers with moderate greenness (Fan et al., 2020); this lack of variability may make it difficult to understand the nuanced effect of greenness on chronic disease outcomes. This association is also complicated by the fact that people move over their lifetime; the CLSA does not include data on measures such as length of residency in a neighborhood for such an analysis.

The lack of associations with Can-ALE data raise some important considerations. The Can-ALE index is comprised of intersection density, dwelling density, and points of interest. While these generally reflect higher walkability, this may not be the case for older adults. In fact, research suggests that more traffic and congestion can be deterrents to outdoor activity in older adults (Klicnik and Dogra, 2019). Thus, perhaps the measure used for assessing walkability in older adults needs to be based on perceptions of the environment. Certainly, such perceptions have been found to be associated with health behaviors such as sedentary time (TV viewing time) (Shibata et al., 2015). We also did not have follow-up data on Can-ALE or NDVI; however, the three factors included in the Can-ALE score and NDVI greenness measure are not expected to change significantly over the short (i.e. 3-year) follow up period. Past research in Canada has also shown that spatial patterns of walkability and urban greenness remain stable over time (Creatore et al., 2016; Czekajlo et al., 2020).

Although we used a chronic disease index based on an evidence-informed model, this measure was not associated with either greenness or walkability. There are three issues to consider here. First, the time between exposure and chronic disease self-report was short. It is possible that associations would be observed over a longer period of time. Second, a more specific aging context may be needed for this work. Most older adults report having at least one chronic condition, while several have multiple comorbidities. However, this simple tally of chronic conditions does not reflect the severity or impact of these chronic conditions on quality of life. Certainly, there is an argument for focusing on geriatric relevant health outcomes such as physical function or quality of life rather than chronic disease (Dogra et al., 2021). Finally, the measures used for chronic disease are based on self-report, which can lead to misclassification; several participants reported no longer having a chronic disease that they reported at baseline despite being asked if they 'ever' had the condition diagnosed by a physician.

The large sample of community dwelling older adults from across Canada, with postal-code level data on the environment was a significant strength of the present analysis. However, the short follow-up period may have limited our ability to observe an effect on chronic disease outcomes as it may take several years of living in a neighborhood before it contributes to disease diagnosis. Using individual diseases instead of an index of chronic conditions may have provided further insight, but our preliminary analysis did not support this approach. Finally, the sample was generally healthy, affluent, and primarily lived in homogenous urban areas.

In conclusion, neighborhood greenness is independently associated with measures of self-rated health among older Canadians.

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CRediT authorship contribution statement

Irmina Klicnik: Conceptualization, Methodology, Formal analysis, Writing – review & editing, Writing – original draft. **Andrew Putman:** Conceptualization, Methodology, Formal analysis, Writing – review & editing, Writing – original draft. **Dany Doiron:** Methodology, Writing – review & editing. **Caroline Barakat:** Conceptualization, Writing – review & editing. **Chris I. Ardern:** Conceptualization, Writing – review & editing. **David Rudoler:** Conceptualization, Methodology, Writing – review & editing. **Shilpa Dogra:** Conceptualization, Methodology, Writing – review & editing, Funding acquisition, Formal analysis, Writing – original draft, Supervision, Project administration, Resources.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data. Data are available from the Canadian Longitudinal Study on Aging (https://www.clsa-elcv.ca) for researchers who meet the criteria for access to de-identified CLSA data.

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The Normalized Difference Vegetation Index and the Canadian Active Living Environments Index (Can-ALE), indexed to DMTI Spatial Inc. postal codes were provided by CANUE (Canadian Urban Environmental Health Research Consortium, https://www.canue.ca).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2022.102018.

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