

BMJ Open Individual physical activity, neighbourhood active living environment and mental illness hospitalisation among adults with cardiometabolic disease: a Canadian population-based cohort analysis

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ABSTRACT

Objectives This population-based observational study explores the associations between individual-level and neighbourhood-level indices of active living with inpatient mental healthcare use among adults with an underlying chronic cardiometabolic condition.

Design and setting Data from the 2013–2014 Canadian Community Health Survey were linked longitudinally to hospital records from the 2013/2014–2017/2018 Discharge Abstract Database and to a geocoded measure of active living environments (ALE). Relationships between individuals' leisure-time physical activity and neighbourhood ALE with risk of hospital admission for mental health disorders were assessed using multivariable Cox regressions.

Participants A national cohort was identified from the survey data of 24 960 respondents aged 35 years and above reporting having been diagnosed with diabetes, hypertension and/or heart disease.

Outcome measure Potentially avoidable hospitalisation for a mood, anxiety or substance use disorder over a 5-year period.

Results More than half (52%) of adults aged 35 years and above with a cardiometabolic disease were physically inactive in their daily lives, and one-third (34%) resided in the least activity-friendly neighbourhoods. The rate of being hospitalised at least once for a comorbid mental disorder averaged 8.1 (95% CI: 7.0 to 9.3) per 1000 person-years of exposure. Individuals who were at least moderately active were half as likely to be hospitalised for a comorbid mental health problem compared with those who were inactive (HR: 0.50 (95% CI: 0.38 to 0.65)). No statistically discernible associations between neighbourhood ALE and hospitalisation risks were found after controlling for individuals' behaviours and characteristics, including in separate models stratified by age group and by sex.

Conclusions The evidence base to support prioritisation of interventions focusing on the built environment favouring mental health-promoting physical activity among higher-risk adults at the population level, independently of individual-level behaviours and characteristics, remains limited.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ Strengths of this national observational study include a large population-based sample, objectively measured active living environments, and a 5-year follow-up period.
- ⇒ The use of multiple linked datasets allowed consideration of individuals' health status, behaviours and sociodemographic characteristics as potential confounders of differential hospitalisation risk.
- ⇒ Limitations include an inability to ascertain whether individuals' leisure-time physical activities occurred in their residential neighbourhoods and perceptions of built environments distinctly from the objectively measured elements.
- ⇒ The study design may have run the risk of bias from residential self-selection.

INTRODUCTION

Over the past few decades, there have been significant increases in physical inactivity-related health conditions, including cardiometabolic diseases and related complications, among Canadians and globally.^{1–4} For example, 8.8% of Canadians were estimated to be diagnosed with diabetes mellitus in 2017, with the age-standardised prevalence rate having increased by 3.3% annually since 2001.⁵ Although the causal direction is not clear, depression and other mental health conditions are increasingly recognised as a complication of diabetes⁶ and, in turn, increased use of hospital services.⁷ The benefits of physical activity for improving symptoms of mental and substance use disorders have been widely acknowledged.⁸ Yet, people experiencing major depression, one of the most common forms of mental illnesses, may engage in less physical activity and exercise than others.⁹ The issue of increasing physical

and mental health conditions related to sedentary lifestyles has prompted interest in facilitating opportunities for daily physical activity, ideally undertaken for leisure or transportation purposes, through modifications to the built environment as population-level health interventions.^{10 11} This notion has been grounded in the conceptualisation of neighbourhoods as opportunity structures for people to acquire (or not) health-promoting resources in everyday life, such as through sidewalks, parks and other traffic-calming instruments favourable to physical activity.¹²

Reviews of the literature have documented associations between neighbourhood built environment characteristics and incidence of chronic diseases, including diabetes,^{13 14} cardiovascular disease¹⁵ and mental health.¹⁶ More specifically, there is increasing evidence that the design of built environments contributes substantially to levels of physical activity.^{17–20} Some socioepidemiological studies have reported associations between indicators of the active living friendliness, or walkability, of neighbourhoods and reductions in: obesity,^{21 22} hospitalisations for myocardial infarction,²³ incident diabetes²² and risks of cardiometabolic mortality.^{24–26} Walking itself has been identified as Canadians' leading activity to stay fit; it is inexpensive and generally possible for individuals of all ages.²⁷ While growing evidence indicates that walking also has benefits to mental health and well-being, recent studies note that the research remains limited and incomplete for associations between individuals' physical activity and their residential built environments with selected mental health outcomes.^{28 29} A small body of literature has found that adults with diabetes residing in poorer or more materially deprived neighbourhoods experience worse mental health outcomes compared with those residing in more affluent neighbourhoods.^{30 31} We are not aware of any studies examining the relationship between neighbourhood active living environments (ALE) and mental disorders among adults at increased risk of severe outcomes, including hospitalisation, due to an underlying cardiometabolic condition.

This novel observational cohort study investigates associations between individual-level and neighbourhood-level indicators of active living and risk of hospitalisation for comorbid mental disorders among adults with selected chronic cardiometabolic diseases. We use multiple types of linked data from national survey, administrative and socioenvironmental sources, acquired through Statistics Canada's Social Data Linkage Environment. Previous studies have used linked data to examine associations between individual-level and residential measures of active living with use of active transportation, self-reported mood and anxiety disorders, and premature cardiometabolic mortality.^{26 29 32} We aim to address the question: do adults 35 years and above with a pre-existing cardiometabolic condition residing in neighbourhoods that are less activity-supportive have higher risk of hospitalisation for mental health and substance use disorders, independently of their physical activity level? Mental disorders

are widely held as ambulatory care sensitive conditions, that is, conditions for which the need for hospital admission can be largely prevented or reduced through appropriate management in primary and community care.³³ We hypothesised that neighbourhood ALE would capture residential clusters designed to combat sedentary lifestyles in mediating the risk of potentially avoidable hospitalisation for these conditions. We further stratified the analysis by age group and by sex, to account for socioenvironmental differences that may distinctly affect health outcomes among younger versus older adults³⁴ and among women versus men.^{35 36}

METHODS

Study design and data sources

This population-based cohort study used data from Statistics Canada's 2013–2014 Canadian Community Health Survey (CCHS)³⁷ linked longitudinally to 5 years of hospitalisation data from the 2013/2014–2017/2018 Discharge Abstract Database (DAD)³⁸ and to the geocoded Canadian Active Living Environments (Can-ALE) database.³⁹ We follow the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.⁴⁰

The CCHS collects information annually on a range of health-related characteristics, behaviours and outcomes among a sample of the community-dwelling population aged 12 years and above. Some groups representing less than 3% of the population are excluded from coverage (eg, persons residing on Indigenous reserves or in some very remote areas, full-time members of the Canadian Forces and the institutionalised population). We considered as the baseline cohort respondents aged 35 years and above who reported in the survey having been diagnosed by a health professional with a cardiometabolic condition, defined here as at least one of diabetes (any type), hypertension or heart disease. To increase the sample size and statistical power of the present analysis, we pooled 2 years of survey microdata (ie, from the 2013 and 2014 rounds) and scaled the sampling weights by a factor of two to ensure national representation.⁴¹

Second, the DAD captures standardised administrative, demographic and clinical information on all hospital stays across Canada (excluding the province of Quebec, which reports hospital morbidity data differently), collated by fiscal year of the discharge date. Diagnostic information for the most responsible reason for each hospital stay were coded to the International Classification of Disease (ICD-10).⁴² Given Canada's publicly funded universal healthcare insurance system, which covers all essential hospital and physician services for all citizens, the data are deemed to reflect a complete recording of inpatient stays. We tracked DAD records over five fiscal years: 2013/2014–2017/2018. The outcome of interest was considered as an individual having experienced a (first) hospitalisation over the 5-year period for a mood disorder (eg, depression), anxiety disorder (eg, social phobia) or substance use disorder (eg, pathological intoxication), as

coded to the ICD-10 standard (codes F10–F19, F30–F42, F44–F48, F55, F68). A previous validation study indicated high specificity and moderate sensitivity when coding depression using the ICD-10 in Canadian administrative health data sources.⁴³

Third, the Can-ALE database was leveraged to enable examination of the independent role of the built environment as a social determinant of hospital-based health outcomes. Made available for research use through the Canadian Urban Environmental Health Research Consortium,⁴⁴ the ALE index is captured on a continuous scale to represent the relative connectivity, density and proximity to destinations for the country's 56 589 census dissemination areas (ie, relatively small geographic units, generally having populations of approximately 400–700 residents and commonly referred to as neighbourhoods).^{39 45} It is based on objectively measured data on road and footpath networks, population and dwelling counts, and locations of shops, schools and other points of interest.³⁹ All individuals residing within a given dissemination area at baseline were assigned the same Can-ALE value. We used the 2016 version of the Can-ALE index, considered to reflect the cohort's environmental context more closely for the period of observation, and assumed to remain relatively stable over the 5-year timeframe. A study from the Canadian province of Ontario found that during 12 years of follow-up, most neighbourhoods remained within the same walkability quintile of their baseline assignment.²²

Respondents to the CCHS were linked to their DAD records by Statistics Canada using probabilistic matching based on common identifiers (names, sex, date of birth and postal code), an approach which has been detailed methodologically elsewhere.^{46 47} For the present research, the deidentified linkable databases were accessed in the secure computing facility of Statistics Canada's Research Data Centre located at the University of New Brunswick. We subsequently linked the person-level data to the Can-ALE by place of residence using a correspondence matching between postal codes and census geographic areas.⁴⁸ All (unweighted) sample counts and (weighted) population estimates reported here have been rounded to meet Statistics Canada data privacy and disclosure protocols.

Target population

The baseline cohort, as drawn from the 2013–2014 CCHS data, included adults aged 35 years and above who self-reported having been diagnosed by a health professional with diabetes, hypertension or heart disease. From the original survey sample of 101 740 respondents who agreed to share and link their data, we excluded from the analysis residents of Quebec given the lack of corresponding DAD data (20 470 or 20%), respondents under the age of 35 years (22 620 or 22%) and those who did not report having one of the selected pre-existing cardiometabolic conditions (31 280 or 31%). This yielded a sample of 27 235 respondents for potential analysis. To control for recent history of acute mental health problems, persons

having been hospitalised for mood, anxiety or substance use disorders in the 4 years preceding baseline were excluded from the study (520 or 2%, based on retrospective DAD data from 2009/2010 to 2012/2013). Also excluded were those lacking valid responses for any of the individual-level confounders (1450 or 5%, per the variables described below) or the postal code linkage to the Can-ALE index (305 or 1%).

The final sample counted 24 960 eligible respondents, which represented a (weighted) synthetic baseline cohort of 5.2 million person-years among adults aged 35 years and above with a cardiometabolic condition. Their data were linked to 670 first admissions for a mood, anxiety or substance use disorder, which represented a (weighted) annual average of 42 400 hospitalisations over the 5-year follow-up period.

Predictor variables

To consider predictors of hospitalisation for mental and behavioural disorders among adults with a chronic cardiometabolic condition, a directed acyclic graph was developed on the role of active living at the neighbourhood and individual levels, adjusted for a set of sociodemographic confounders (figure 1).⁴⁹ Chronic stress was diagrammed as a confounder, but the causal pathways through which this factor may lead to an incident mood, anxiety or substance use problem, in turn fuelling the risk of a potentially avoidable hospitalisation, remain understudied in the literature and unmeasured in the available data.

We organised and ranked the baseline cohort by neighbourhood ALE into quintile groups against the national distribution, that is, quintile 1 as the 20% of adults with a cardiometabolic condition residing in areas of the country with the least favourable ALE (also referred to as the least activity-friendly neighbourhoods) and quintile 5 as the 20% of the study population residing in the most favourable ALE (or highest activity-friendly neighbourhoods).

The individual-level active living indicator was measured from the CCHS data, which categorised respondents as being active, moderately active or inactive in transportation and leisure time based on a series of questions used for estimating total daily energy expenditure tallied across a mix of physical activities in the previous 3-month period, such as walking for exercise, jogging, bicycling, gardening or playing sports.³⁷ An earlier comparative study noted some discrepancies between survey responses versus objective accelerometer-measured physical activity, but could not ascertain either data collection method as necessarily more valid: while survey data present the risk of recall and social desirability bias for self-reported activities, accelerometry data are also limited with respect to accurately measuring certain activities such as bicycling and swimming.⁵⁰

We further considered a parsimonious set of individual-level biodemographic, socioeconomic and behavioural covariates, as captured in the CCHS, as tracers for differential risk of adverse health outcomes and hospitalisation.

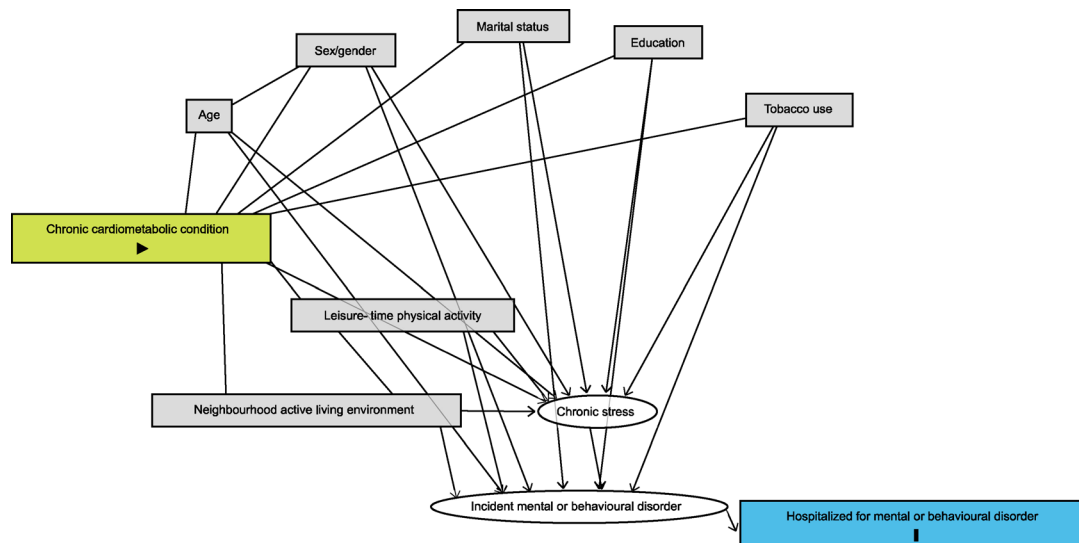


Figure 1 Directed acyclic graph to identify confounders of the risk of potentially avoidable hospitalisation for mental and substance use disorders among adults with an underlying cardiometabolic condition.

Specifically, age was measured as a time-varying variable (ie, from age at baseline to age at hospitalisation or the end of the study period for those not hospitalised), covering three broad groups across the adult life span: 35–54 years, 55–74 years and 75 years and above. Sex was measured as a time-invariant variable as male or female, based on the available data. Also included in the analysis was the person's marital status (whether or not currently in a marital/common-law union), educational attainment (whether or not at least some postsecondary schooling was attained) and smoking status (whether or not currently a daily/occasional tobacco smoker).³⁷

Statistical analysis

Following a brief descriptive data analysis, multivariable Cox proportional hazards regression models were used to examine associations between the individual and contextual measures of active living with the time to first occurrence of a hospitalisation for a mental health or substance use disorder, controlling for sociodemographic characteristics. Six separate models were run, first for the total target population and then stratified by the two sexes and by the three age groups. Bootstrapped sampling weights were applied to the linked data to ensure population representation of the HRs and robust 95% CIs.

Patient and public involvement

No patients were involved in this secondary analysis of existing databases.

RESULTS

Descriptive analysis

As seen in [figure 2](#), the target population of cardiometabolically unhealthy adults was distributed evenly by sex. Most (70%) were cohabitating in a marital or common-law union, 59% had attained at least some postsecondary education and 16% were current tobacco smokers. Over

half (52%) were physically inactive in their daily lives, and one-third (34%) resided in neighbourhoods scoring in the lowest quintile on the ALE scale.

The rate of being hospitalised at least once for a comorbid mood, anxiety or substance use disorder over the 5-year observation period averaged 8.1 (95% CI: 7.0 to 9.3) per 1000 person-years among adults with diabetes, hypertension or heart disease. The proportions of individuals experiencing a mental health-related hospitalisation tended to be higher among those who were older, not cohabitating with a marital partner, having at most a secondary education level or tobacco smokers ([figure 3](#)). The annual hospitalisation rate averaged significantly higher among individuals who were physically inactive in their daily lives (11.1 (95% CI: 9.3 to 12.9) first admissions per 1000 person-years) compared with those who were at least moderately active (4.8 (95% CI: 3.8 to 6.0)). No obvious pattern in terms of differences in the hospitalisation rate was observed among residents of the least activity-friendly neighbourhoods (8.6 (95% CI: 7.0 to 10.2) per 1000 person-years) versus residents of moderately activity-friendly areas (7.5 (95% CI: 5.6 to 9.5)) or the most favourable activity-friendly areas (8.1 (95% CI: 6.0 to 10.3)).

Multivariable analysis for predictors of mental health-related hospitalisation

Results of the Cox regression analysis for the total population cohort showed that adults with an underlying cardiometabolic condition who were at least moderately physically active had a significantly lower risk of hospitalisation for a comorbid mood, anxiety or substance use disorder (HR: 0.50 (95% CI: 0.38 to 0.65), $p < 0.05$) ([table 1](#), model 1). In terms of neighbourhood ALE, although there was a suggestion of a risk gradient, with residents of the least activity-friendly neighbourhoods somewhat more likely to be hospitalised than those residing in more

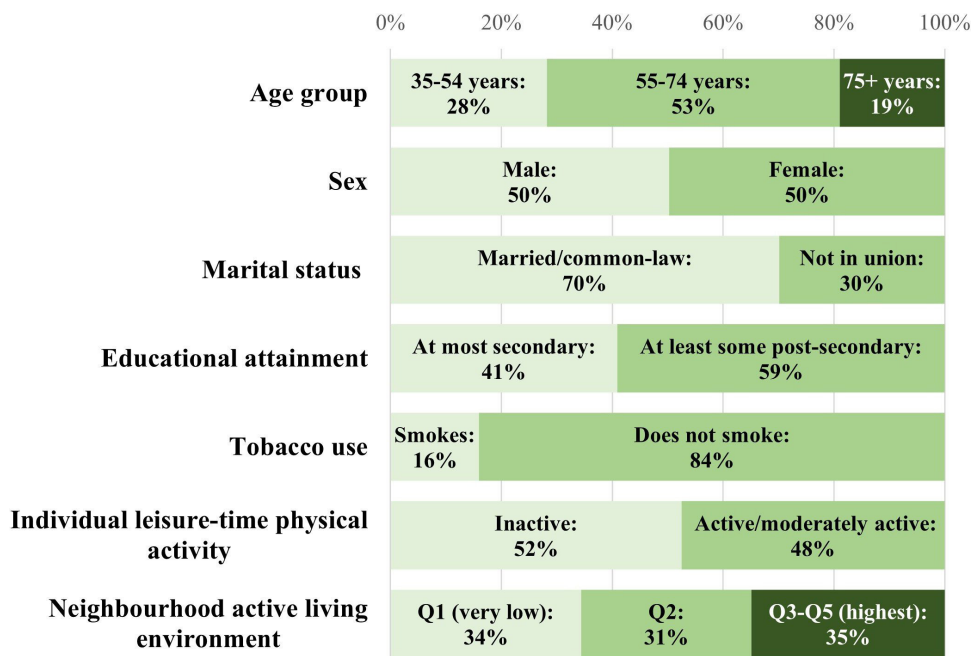


Figure 2 Percentage distribution of the population cohort aged 35 years and above with diabetes, hypertension and/or heart disease, by selected individual and neighbourhood characteristics. Characteristics measured at baseline. Residents stratified by neighbourhood active living environment, with quintile 1 (Q1)=least activity-friendly neighbourhoods and quintiles 3–5 (Q3–Q5)=most activity-friendly areas. Source: Canadian Community Health Survey 2013–2014 (n=24 960) linked to Can-ALE Index.

activity-friendly neighbourhoods (HR: 1.14 (95% CI: 0.84 to 1.55)), the association was not statistically significant after controlling for individual-level behaviours and other factors. There was no significant difference by the person's sex. Refraining from smoking tobacco, having a postsecondary level of schooling and cohabitating with a partner were found to be independently protective of mental health-related hospitalisation risk.

The same general patterns of individual and neighbourhood measures of active living held in the sex-disaggregated models, among both men (table 1, model 2) and women (table 1, model 3). Men with a cardiometabolic condition who were active or moderately active were approximately half as likely to experience a mental health-related hospitalisation (HR: 0.55 (95% CI: 0.37 to 0.82), $p < 0.05$). Similarly, women who were at least moderately active had a significantly lower hospitalisation risk (HR: 0.43 (95% CI: 0.29 to 0.52), $p < 0.05$), all else being equal. In each of the sex-disaggregated models, neighbourhood ALE was not found to exercise a significant influence on hospitalisation risk after adjusting for other person-level characteristics.

Regarding the age-disaggregated models, the inverse association between individuals' leisure-time physical activity with the risk of being hospitalised at least once for a mental health-related hospitalisation held as significant among older adults aged 55–74 years (HR: 0.40 (95% CI: 0.29 to 0.56)) (table 2, model 2). The associations were not statistically discernible among younger adults aged 35–54 years (HR: 0.62 (95% CI: 0.31 to 1.25)) (table 2, model 1) or among the oldest adults aged 75 years and above (HR: 0.67 (95% CI: 0.43 to 1.07)) (table 2, model

3). In none of the three age-specific models was neighbourhood ALE found to have an independent relationship with hospitalisation risk, after controlling for other factors.

DISCUSSION

This population-based cohort study sourced and linked multiple datasets from surveys, administrative health records and geocoded measures of active living to investigate the risk of potentially avoidable hospitalisation for mental disorders among adults with an underlying cardiometabolic condition. Among Canadians aged 35 years and above with diabetes, heart disease and/or hypertension, and after censoring those with a recent history of severe mental disorders, the rate of being hospitalised at least once for a mood, anxiety or substance use disorder averaged 8.1 (95% CI: 7.0 to 9.3) per 1000 person-years of exposure. The multivariate analysis showed a significant independent association between the risk of comorbid mental health-related hospitalisation with individuals' leisure-time physical activity: those who were moderately active or active in their daily lives were approximately half as likely to be hospitalised compared with their inactive counterparts (HR: 0.50 (95% CI: 0.38 to 0.65)), all else being equal.

Contrary to our initial hypothesis, no significant relationship was found between neighbourhood ALE and mental health-related hospitalisation risk, adjusting for individual-level characteristics and behaviours. This result may reflect the limited statistical power offered by our study cohort, given the relative rarity of adult

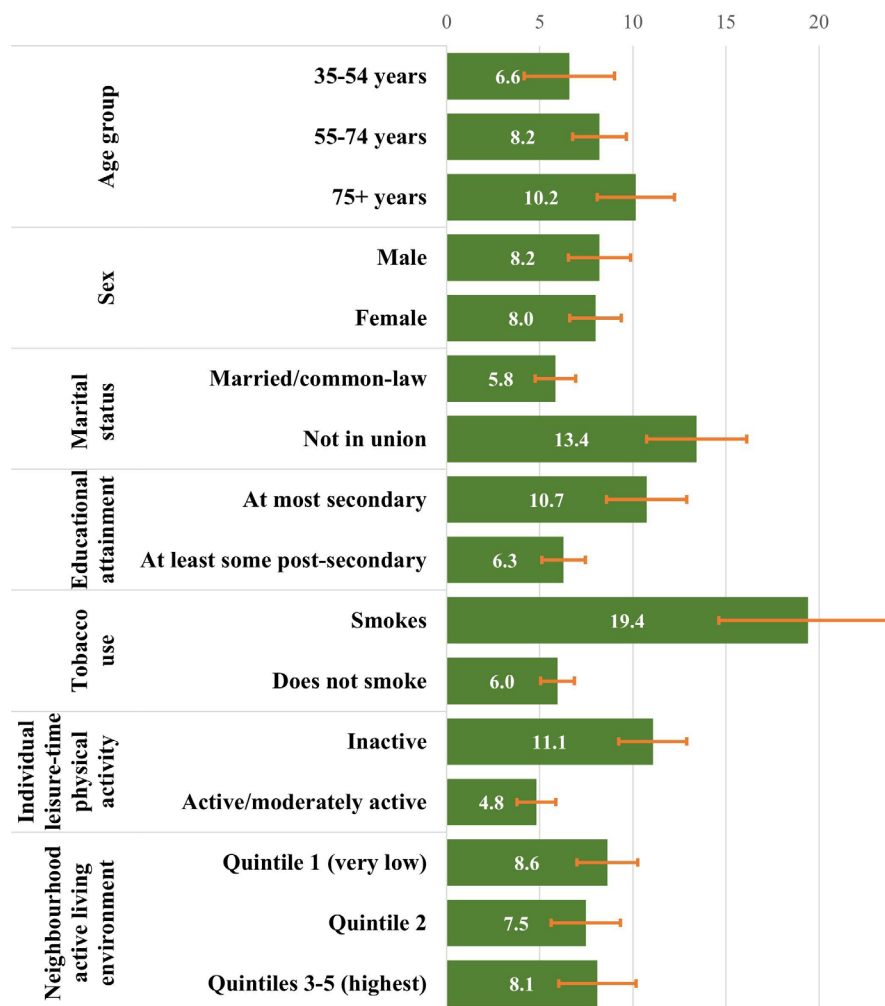


Figure 3 Rate of a first hospitalisation for a mood, anxiety or substance use disorder among the adult population with a cardiometabolic condition (per 1000 person-years of exposure, with 95% CIs), by selected individual and neighbourhood characteristics. Note: Characteristics measured at baseline. Residents stratified by neighbourhood active living environment, with quintile 1 (Q1)=least activity-friendly neighbourhoods and quintiles 3–5 (Q3–Q5)=most activity-friendly areas. Source: Canadian Community Health Survey 2013–2014 (n=24 960) linked to 2013/2014–2017/2018 Discharge Abstract Database (n=670) and to Can-ALE Index.

hospitalisations for mood, anxiety and substance use disorders (N=670 admissions), particularly since the data did not cover persons who may have presented to the emergency department but were not admitted for inpatient care. Hospitalisations are indicative of a more severe course of mental illness, and may represent the ‘tip of the iceberg’ for mental health issues and challenges in accessing community-based care. Given the focus of this study on a specific subpopulation, the lack of statistical association between neighbourhood ALE and hospitalisation could thus be a manifestation of the different groups with mental health or substance use disorders, notably such that we may be missing those who would benefit the most from high activity-friendliness of their communities and thus delay or prevent the onset of a cardiometabolic condition. It may also reflect an incomplete conceptualisation and operationalisation of the features of neighbourhoods that may favour active living, such as opportunities for healthy eating in the community.⁵¹ Examinations

across different contexts have returned inconsistency in the significance of any association between specific neighbourhood attributes and mental health outcomes.⁵²

As the knowledge base on relationships between neighbourhood built environments and health outcomes in the general population continues to develop, there is growing interest in establishing the connections between health and place for specific populations in an ageing world.³⁴ It has been postulated that the role of residential built neighbourhoods on older adults’ health may be intensified given their decreased mobility; however, research on neighbourhood ALE among older adults has been limited and mostly based on cross-sectional observations.³⁴ Our longitudinal analyses stratified across adult age groups did not find statistical evidence of a protective effect of objectively measured neighbourhood active living friendliness on mental health-related hospitalisations among higher-risk older adults. Studies have suggested perceptions of neighbourhood resources and

Table 1 Adjusted HRs and 95% CIs for the risk of being hospitalised for a mood, anxiety or substance use disorder among the population aged 35 and over with a cardiometabolic condition, total and by sex

Characteristic	(1) Total—both sexes			(2) Men			(3) Women		
	HR	95% CI	P value	HR	95% CI	P value	HR	95% CI	P value
Neighbourhood active living environment (ref: Q3–Q5 highest)									
Q1 (very low)	1.14	0.84 to 1.55	0.40	0.91	0.58 to 1.42	0.68	1.42	0.91 to 2.20	0.12
Q2	1.01	0.72 to 1.42	0.94	0.88	0.57 to 1.37	0.58	1.19	0.74 to 1.92	0.46
Individual leisure-time physical activity (ref: inactive)									
Active/moderately active	0.50*	0.38 to 0.65	<0.01	0.55*	0.37 to 0.82	<0.01	0.43*	0.29 to 0.63	<0.01
Age group (ref: 35–54 years)									
55–74 years	1.20	0.69 to 2.09	0.53	1.56	0.78 to 3.13	0.21	0.93	0.40 to 2.13	0.86
75+ years	1.33	0.74 to 2.41	0.34	1.50	0.75 to 3.01	0.25	1.30	0.51 to 3.29	0.58
Sex (ref: male)									
Female	0.86	0.65–1.14	0.29	–			–		
Marital status (ref: not in union)									
Married/common law	0.50*	0.38 to 0.65	<0.01	0.35*	0.25 to 0.50	<0.01	0.71*	0.49 to 1.04	0.08
Educational attainment (ref: at most secondary schooling)									
Some post secondary	0.72*	0.54 to 0.96	0.03	0.70	0.46 to 1.07	0.10	0.76	0.51 to 1.13	0.17
Tobacco use (ref: does not smoke)									
Smokes	2.80*	2.11 to 3.71	<0.01	2.22*	1.48 to 3.33	<0.01	3.53*	2.39 to 5.20	<0.01

Residents stratified by neighbourhood active living environment, with quintile 1 (Q1)=least activity-friendly neighbourhoods and quintiles 3–5 (Q3–Q5)=most activity-friendly areas.

Source: Canadian Community Health Survey 2013–2014 (n=24 960) linked to 2013/2014–2017/2018 Discharge Abstract Database (n=670) and to Can-ALE Index.

*P<0.05.

ref, reference category.

Table 2 Adjusted HRs and 95% CIs for the risk of being hospitalised for a mood, anxiety or substance use disorder among the adult population with a cardiometabolic condition, by age group

Characteristic	(4) Ages 35–54 years			(5) Ages 55–74 years			(6) Ages 75 years and above		
	HR	95% CI	P value	HR	95% CI	P value	HR	95% CI	P value
Neighbourhood active living environment (ref: Q3–Q5 highest)									
Q1 (very low)	1.49	0.65 to 3.43	0.34	0.97	0.67 to 1.40	0.88	1.36	0.81 to 2.30	0.25
Q2	1.04	0.34 to 3.19	0.95	0.95	0.62 to 1.45	0.82	1.09	0.64 to 1.86	0.75
Individual leisure-time physical activity (ref: inactive)									
Active/moderately active	0.62	0.31 to 1.25	0.18	0.40*	0.29 to 0.56	<0.01	0.67	0.43 to 1.07	0.10
Sex (ref: male)									
Female	0.79	0.38 to 1.62	0.52	0.83	0.58 to 1.20	0.32	1.13	0.65 to 1.94	0.67
Marital status (ref: not in union)									
Married/common law	0.52	0.25 to 1.06	0.07	0.44*	0.32 to 0.61	0.00	0.79	0.45 to 1.37	0.39
Educational attainment (ref: at most secondary schooling)									
Some post secondary	0.33*	0.13 to 0.81	0.02	0.89	0.64 to 1.25	0.52	1.03	0.67 to 1.59	0.89
Tobacco use (ref: does not smoke)									
Smokes	1.68	0.78 to 3.64	0.19	3.93*	2.84 to 5.42	<0.01	1.70	0.90 to 3.24	0.10

Residents stratified by neighbourhood active living environment, with quintile 1 (Q1)=least activity-friendly neighbourhoods and quintiles 3–5 (Q3–Q5)=most activity-friendly areas.

Source: Canadian Community Health Survey 2013–2014 (n=24 960) linked to 2013/2014–2017/2018 Discharge Abstract Database (n=670) and to Can-ALE Index.

*P<0.05.

ref, reference category.

problems may be more salient to higher-risk adults' health and well-being than objective measures of walkability.^{34 53} Similarly, and consistent with some research elsewhere using objectively collected data on neighbourhood characteristics,³⁶ we found no clear division between women and men in the associations between neighbourhood physical environments and health. Distinguishing neighbourhoods based on physical attributes alone may be problematic, as it is possible that women's social roles and vulnerabilities may be linked to greater dependence than men on perceptions of their local environments, such as a fear of walking alone after dark and other chronic stressors.^{35 36} More research is needed incorporating indicators of both perceived and objective neighbourhood health-promoting opportunities.

Residential self-selection is a potential confounding issue for this observational study, namely that certain people may choose to reside in more activity-friendly neighbourhoods. It is also possible that some individuals may have received a diagnosis of a cardiometabolic condition on hospitalisation after interview at baseline. Another limitation of this study, inherent to longitudinal designs, is the likelihood of some loss to follow-up, such as due to moving outside of a jurisdiction with available DAD data or due to death outside of a hospital setting. Another challenge is possible misclassifications of neighbourhood ALE during the database linkages based on postal code correspondence with the census geographies. This matching process is widely used in spatial analyses of health and has been assessed as relatively accurate at the level of census dissemination areas in urban centres, but less so in rural areas.⁵⁴ Existing measures of the active living friendliness of a neighbourhood, such as captured in the Can-ALE index, tend to emphasise aspects of 'walkability' in terms of supporting healthy activity behaviours at the population level that may be influenced by local urban form, density and street layouts.⁵⁵ Previous research on the mental health implications of neighbourhood socio-environments in a semirural Canadian province proposed that, in smaller urban and rural settlements, indicators of ALE may be little more than a marker for the urban cores.⁵⁶ Evidence from adults' lived experiences suggests the contextual enablers and barriers to physical activity may differ in urban areas (eg, pedestrian infrastructure, nearby destinations) versus rural areas (eg, presence of large vehicles and winding roads).⁵⁷

The prescribing of 'exercise as medicine' has been widely shown to offer positive mental health benefits among those with elevated symptoms, and with few adverse events.⁸ This study highlights that much remains unknown to support evidence-based prioritisation of interventions focusing on physical environments to promote exercise among higher-risk adults at the population level, independently of individual-level behaviours and characteristics.

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Contributors NG and DLC conceptualised the study. NG led the writing of the manuscript. PM performed the data management and formal analysis. All authors (NG, DLC, PM and TT) contributed to the study design and results interpretation. All authors read and approved the final version. NG accepts full responsibility for the conduct of the study and controlled the decision to publish.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Informed consent to participate in the Canadian Community Health Survey and to allow linkage of survey responses with administrative data was obtained by Statistics Canada. Additional internal ethical review for research using national statistical sources accessed in the NB-RDC was not required for this study, in accordance with institutional requirements of the University of New Brunswick Research Ethics Board.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data may be obtained from a third party and are not publicly available. The data that support the findings of the study are available through Statistics Canada's Research Data Centres but restrictions apply to the public availability of these confidential data, which were used with permission for the current study. Researchers who meet the eligibility criteria to access the microdata may submit an application at: www.statcan.gc.ca/en/microdata/data-centres/access.

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