



Rural and urban variation in psychological distress among adults: results of the 2014–2015 Eastern Townships Population Health Survey (ETPHS)

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Abstract

Objective A growing number of people live in urban areas. Urbanization has been associated with an increased prevalence of mental disorders, but which mechanisms cause this increase is unknown. Psychological distress is a good indicator of mental health. This study sought to examine the relationship between urbanization and distress among adults in the Eastern Townships (southern region of Quebec, Canada).

Method In the 2014–2015 Eastern Townships Population Health Survey ($N = 10,687$ adults living in one of the 96 Eastern Townships communities), distress was measured with the K6 distress scale (≥ 7). Urbanization was estimated by the residential density of the community treated in quintiles. Logistic regression analyses were carried out with adjustments for individual and environmental characteristics.

Results Women, young people aged 18–24, single parents, those without diplomas, those without a job, those with $< \$20,000$ in income, adults with two or more chronic physical illnesses, adults with bad perceived health, or those living in disadvantaged neighbourhoods exhibited more distress. The unadjusted estimate between density and distress is only significant for the fifth quintile when compared with the first quintile (OR 1.23; 95% CI: 1.06–1.42). The relationship is practically the same after controlling for individual characteristics but decreases considerably after controlling for environmental characteristics (lack of trees, social deprivation, intersection density, vegetation index, and land use mix).

Conclusion This study was the first to examine an association between urbanization and distress by considering individual and environmental characteristics. The latter seem to explain the relationship between these concepts.

Résumé

Objectif Un nombre croissant de personnes vivent en milieu urbain. L'urbanisation a été associée à une prévalence accrue de troubles mentaux, mais on ignore par quels mécanismes. La détresse psychologique est un bon indicateur de la santé mentale. Cette étude cherche à examiner le lien entre l'urbanisation et la détresse des adultes en l'Estrie (région dans le sud du Québec, Canada).

Méthode Dans l'Enquête de santé populationnelle estrienne 2014–2015 ($N = 10\,687$ adultes, résidant dans l'une des 96 communautés estriennes), la détresse a été mesurée avec le Kessler-6 (score ≥ 7). L'urbanisation a été estimée par la densité résidentielle de la communauté traitée en quintiles. Des analyses de régression logistique ont été réalisées, avec ajustement pour des caractéristiques individuelles et environnementales.

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Résultats Les femmes, les 18-24 ans, les personnes monoparentales, celles ne possédant pas de diplôme, sans emploi, ayant un revenu < 20 000\$, ayant deux maladies chroniques ou plus, ayant une mauvaise perception de leur santé, ou vivant dans les quartiers défavorisés présentent plus de détresse. La relation brute entre la densité et la détresse n'est significative que pour la dernière catégorie avec un RC 1,23; IC95% : 1,06–1,42 (Q5 vs Q1). En contrôlant pour les caractéristiques individuelles, la relation demeure pratiquement inchangée, mais diminue davantage après un contrôle pour les caractéristiques environnementales (manque d'arbres, défavorisation sociale, densité d'intersections, indice de végétation et mixité des sols).

Conclusion Cette étude est la première à examiner une association entre l'urbanisation et la détresse en considérant les caractéristiques individuelles et environnementales. Ces dernières semblent expliquer la relation entre ces concepts.

Keywords Psychological distress · Rural-urban · Built environment

Mots-clés Détresse psychologique · urbain rural · environnement bâti

Introduction

In Canada, according to the most recent data, in 2018, 81% of Canadians were living in urban areas, whereas for the rest of the world, 55% were in an urban environment, and the trend is increasing (UN 2018). Living in urban areas has been linked to various issues, such as poverty, pollution, homelessness, and concentration of mental health disorders (Srivastava 2009). Many published studies suggest a positive relationship between urbanization and mental disorders. Among others, a meta-analysis by Peen et al. (2010) concludes that mood and anxiety disorders are more prevalent in urban areas than in rural areas. However, we know very little about the mechanisms that could explain this relationship.

A good indicator of overall mental health is psychological distress. Including symptoms of preclinical depression and anxiety, this nonspecific mental health measure is very useful for establishing a portrait of the general population's mental health (Drapeau et al. 2011). In Quebec and in the Eastern Townships, 28.3% and 27.6% of the population (≥ 15 years old) reported experiencing psychological distress. For larger regions such as Montreal and Laval, 30.8% and 31.5% reported having distress (Camirand et al. 2016). Nevertheless, there are few studies on the association between place of residence (urban vs. rural) and psychological distress. Five studies directly address the issue, and conclusions do not all point in the same direction. While a study by Dhingra et al. (2009; USA) concludes that people in urban areas exhibit a higher risk of distress than those in rural areas, a study by Stickley et al. (2015; nine countries from the former USSR) reaches the opposite conclusion. For their part, studies by Oguzturk (2008; Kirikkale, Turkey) and Shirolkar and Prakash (1996; Bangalore, India) show a higher percentage of distress in rural areas, whereas the result of a study by Jalaludin and Garden (2011; Sydney, Australia) is not significant. Note that no study specifically tackling the relationship between urbanization and psychological distress seems to have been carried out in Canada, which makes it all the more difficult to extrapolate

from the studies reviewed to a local context given that living in an urban or rural area is different from one part of the world to the other.

Several individual characteristics are well defined as influencing psychological distress: women are more prone to distress than men; young people are also more affected, and distress decreases with age; and low socio-economic status (SES; low level of education, unemployment, or low income) is also linked to increased distress (Price et al. 2008; Drapeau et al. 2011). Finally, the presence of chronic diseases, stressful events, and situations, as well as some risk behaviours, such as alcohol abuse, are all risk factors of distress (Gill et al. 2009).

Beyond individual characteristics, many articles address the effect of one's living environment on distress. Regarding environmental characteristics linked to distress, a systematic review of the literature by Gong et al. (2016) has made it possible to identify several urban characteristics associated with a higher level of distress, namely, a negative perception of the neighbourhood because of violence, crime, and graffiti, as well as the lack of green spaces, walkability, and access to public transport (Melis et al. 2015). In addition, a neighbourhood-wide low SES (% of poor households, % of single-parent families, % of unemployed) is connected to increased distress (Kim 2008). All of these results highlight the need to better understand if, and how, the urban environment influences distress to identify solutions for preventing mental health disorders in urban areas.

This study is therefore relevant, considering urbanization and the high prevalence of psychological distress in the Eastern Townships (27.6%), as well as current gaps in understanding the effect of urbanization on distress in a Canadian context. The ETPHS, carried out in 2014 and 2015 with a large representative sample of Eastern Townships adults, was an opportunity to further our knowledge on the subject. With this population database, we sought to reach the three following

objectives: (1) to describe the overall prevalence and distribution of psychological distress in the Eastern Townships according to different socio-demographic characteristics measured at the individual and residential community levels; (2) to examine the association between rural or urban place of residence and psychological distress, independently from individual characteristics; and (3) to examine the roles of behavioural and environmental (social and physical) characteristics on the association between place of residence and distress.

Conceptual framework

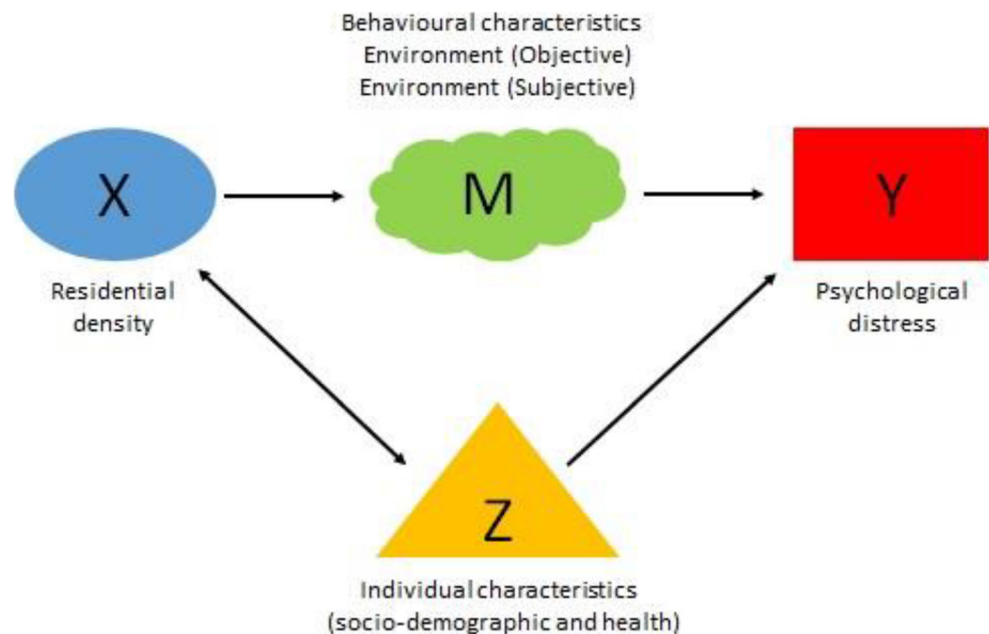
A conceptual framework was developed according to current knowledge for the purpose of this study (Fig. 1). This framework begins by identifying socio-demographic characteristics, at the individual and neighbourhood levels, that may act as confounding factors between urbanization and distress. These characteristics can be tied to, but not caused by, residential density (independent variable or *X*) and be a cause of distress (dependent variable or *Y*). In other words, these variables are linked to both *X* and *Y*. For behavioural (e.g., alcohol abuse) and environmental (e.g., lack of green spaces) factors, the hypothesis is that they can act as mediators in this relationship because, in addition to being linked to urbanization and distress, they possibly consist of an intermediate step between these two variables. To our knowledge, this study is the first that takes into consideration the role of environment (both objective and subjective) on the relationship between urbanization and distress in a Canadian context.

Method

Data

This study is a secondary analysis of 2014–2015 ETPHS data. ETPHS is a cross-sectional study that sought to measure the prevalence and distribution of public health issues in the Eastern Townships by telephone survey. The target population of the ETPHS was adults aged 18 years and older, living in private households in the Eastern Townships. Sampling was stratified according to the local health and social services network (*réseau local de services* (RLS)) and boroughs in Sherbrooke. In April 2015, when the *Centre intégré universitaire de santé et de services sociaux de l’Estrie—Centre hospitalier universitaire de Sherbrooke* (CIUSSS de l’Estrie–CHUS) was created, the health region included two more RLSs, for a total of nine RLSs divided in 96 residential communities that are finer geographical entities than RLSs and more homogenous regarding residents’ characteristics (CIUSSS de l’Estrie – CHUS 2015; OEDC 2019). All of the survey’s subjects were recruited by a specialized polling firm through random digit dialing, which included both landline and cell phone numbers. Regular calls were made between 10 am and 9 pm and between 3 pm and 9 pm on Sundays. Scheduled calls and unanswered calls were called approximately 17 times. The participants could also answer the questionnaire by themselves online. For the survey, the quota was to recruit 800 people per RLS and 800 people per borough in Sherbrooke, except for the boroughs of Brompton and Lennoxville (350 subjects each). The final sample consisted of 10,687 completed interviews in 2014 or 2015, which represented a response rate of 48.5% obtained with the admissibility

Fig. 1 Conceptual framework of the association between residential density and psychological distress with the confounding and mediating variables



of the subjects contacted and those who were never able to be reached.

Measures

Psychological distress

Distress was measured with the K6 distress scale. This questionnaire counts six items concerning depression and anxiety symptoms experienced in the previous month. The six questions are: During the previous month, how frequently did you feel: (1) Nervous, (2) Desperate, (3) Agitated, (4) So depressed that nothing could make you smile, (5) Everything was an effort, and (6) Good for nothing (Kessler et al. 2002). Five answers are possible, and a score of 0 to 4 is associated with each: Never (0 points), Rarely (1 point), Sometimes (2 points), Most of the time (3 points), and All of the time (4 points). An overall score is calculated (between 0 and 24), with a higher score indicating greater distress. A well-established threshold is 13 or more, which corresponds to severe distress (Kessler et al. 2003). Others also propose a threshold of seven or more to identify moderate or severe distress (Camirand et al. 2016). In the present study, these two thresholds were retained to create a variable with three levels (0–6; 7–12; 13 or more). In addition, with its good internal consistency (Cronbach's $\alpha = 0.89$) and its ability to discriminate a case from a noncase of psychological distress, the Kessler scale is a tool of choice frequently used to measure the prevalence of distress in population surveys (Kessler et al. 2002).

Urbanization

Urbanization was determined by six-digit postal codes asked for during the interview. Each postal code was then associated with one of the 96 residential communities in the Eastern Townships. As suggested in other studies, community population density (inhabitant/km² of habitable area) was used as a proxy to measure the degree of urbanization (Peen et al. 2010; Alkema et al. 2013). Thus, the more a community was densely populated, the more it was considered urban. The residential densities measured at the level of the 96 communities were separated in quintiles, in which the first represented the least dense communities.

Individual characteristics

The following socio-demographic variables, all measured at the individual level, were considered as potential confounding factors: sex (male/female), age (18–24/25–34/35–44/45–54/55–64/65+), household composition (single/single with children/couple or other adult without children), highest diploma obtained (none/secondary or professional/collegial/

university), employment status (full-time/part-time/unemployed/retired and semiretired), and household income (less than \$19,999/\$20,000–\$49,999/\$50,000–\$79,999/over \$80,000). Additionally, the number of chronic physical illnesses (none/one/two or more) and perceived health (excellent or really good/good/fair or bad) were taken into consideration.

Behavioural characteristics

Three behavioural variables measured at the individual level were considered as potential mediators, namely, alcohol abuse (five glasses or more on a single occasion, less than once a week/once or more a week), weekly use of cannabis (less than once a week/once or more a week), and the regular practice of physical activities (less than 30 min a day/30 min or more a day).

Environmental characteristics (objective and subjective measures)

Fifteen environmental factors were taken into consideration. On the one hand, six objective variables (social disadvantage index, material disadvantage index, intersection density, land use mix, vegetation index, and % of major renovations required) at the level of the 96 residential communities were divided into quintiles. On the other hand, nine subjective variables (participants' perception with respect to their residential neighbourhood), part of the ETPHS, were treated as categories. The sense of safety relative to the residential neighbourhood (Absolutely or Fairly safe/Little or Not at all safe), the sense of belonging (Very strong or Fairly strong/Fairly weak or Very weak), and the sense of satisfaction (Absolutely or Fairly/Little or Not at all satisfied) were treated as dichotomous. Issues regarding lack of trees, lack of sidewalks, access to green spaces, access to buses, access to medical clinics, and access to community services were treated in three categories (Very big or Fairly big problem/Small problem/No problem).

Analyses

To reach objective 1, descriptive statistics were carried out on the different socio-demographic variables. For objectives 2 and 3, bivariate and multivariate logistic regression analyses were carried out with SPSS 24 software ($\alpha = 0.05$). First, only density was included. Second, the socio-demographic control variables that were individually associated with both density and distress were integrated into the model (objective 2). Third, the behavioural and environmental variables were tested one at a time to determine their role as mediators. To examine the potential mediating role of these variables, the four steps of the Baron and Kenny (1986) method were executed. Finally, only the variables with a mediating potential were taken into consideration in the final regression model, in

Table 1 Psychological distress ($K6 \geq 7$) according to different individual and environmental characteristics

Variables	N (%)
Overall psychological distress	2535 (23.7)
Individual characteristics	
Sex [‡]	
Female	1474 (25.5)
Male	1061 (21.6)
Age [‡]	
18–24 years old	85 (30.7)
25–34	236 (24.7)
35–44	388 (26.0)
45–54	454 (24.0)
55–64	685 (24.7)
65+	646 (20.5)
Highest level of education completed [‡]	
None	412 (32.5)
Secondary/professional	993 (26.1)
Collegial	524 (23.0)
University	593 (18.1)
Employment [†]	
Full-time	1050 (22.2)
Part-time	227 (25.9)
Unemployed	412 (37.5)
Retired/semiretired	814 (21.0)
Household income [‡]	
Less than \$19,999	489 (37.7)
\$20,000–\$49,999	1046 (26.7)
\$50,000–\$79,999	471 (19.2)
More than \$80,000	391 (15.9)
Household composition [‡]	
Single	775 (29.2)
Single with children	121 (33.1)
Couple or other adult without children	1081 (21.0)
Couple or other adult with children	552 (22.2)
Chronic physical illness [‡]	
None	1215 (20.9)
One	775 (24.4)
Two or more	545 (32.1)
Perceived health [‡]	
Excellent or really good	994 (16.8)
Good	866 (27.5)
Fair or bad	675 (42.1)
Environmental characteristics	
Residential density (inhabitant/km ²) [†]	
1st quintile: 1–18.03	612 (22.7)
2nd quintile: 18.04–65.92	537 (24.7)
3rd quintile: 65.93–398.32	462 (21.7)
4th quintile: 398.33–1847.02	429 (22.5)
5th quintile: 1847.03–5337.45	390 (26.5)

Table 1 (continued)

Variables	N (%)
Material deprivation [‡]	
1st quintile (least deprived)	330 (18.8)
2nd quintile	470 (21.5)
3rd quintile	336 (23.6)
4th quintile	524 (24.7)
5th quintile (most deprived)	770 (26.6)
Social deprivation [†]	
1st quintile (least deprived)	457 (22.5)
2nd quintile	631 (23.6)
3rd quintile	510 (23.1)
4th quintile	399 (21.5)
5th quintile (most deprived)	433 (26.9)

[†] $p < 0.01$

[‡] $p < 0.001$

addition to the socio-demographic variables (objective 3). All analyses were weighted for age and sex to ensure better sample representativeness.

Results

Table 1 shows descriptive statistics that meet objective 1. Prevalence of distress across the sample was 23.7%, that is, 21.1% of moderate distress (7–12) and 2.6% of severe distress (13 or more). Women, young people aged 18–24, adults living alone with children, those without a diploma, adults without a job, those with a low income (less than \$19,999), and those with two or more chronic physical illnesses and bad perceived health were the groups presenting the highest prevalence of distress. In addition, the densest communities, as well as the most disadvantaged materially and socially, were groups in which distress was the highest (26.5%, 26.6%, and 26.9% respectively).

Table 2 shows the results of logistic regression analyses examining the relationship between residential density and distress (objective 2), as well as the impact of environmental characteristics on this relationship (objective 3). For model 1, using the first quintile of density as a reference, only the fifth quintile presented a significant difference (OR 1.23; 95% CI: 1.06–1.42). No trend was observed between the five categories of density. By adjusting for individual socio-demographic and health-related variables (model 2), the relationship between density (5th quintile vs. 1st quintile) and distress was no longer significant (OR 1.10; 95% CI: 0.94–1.29), without diminishing considerably. The mediating variables included in model 3, that is, those for which the four steps by Baron and Kenny (1986) were followed, were the following: lack of trees, social disadvantage, intersection density, vegetation index, and land use mix.

Table 2 Logistic regression of the association between residential density and psychological distress (K6 ≥ 7) by controlling for individual and environmental variables

	Model 1 (density)	Model 2 (density + individual)	Model 3 (density + individual + environment)
Independent variable			
Residential density (inhabitant/km ²)			
1st quintile: 1–18.03	Ref	Ref	Ref
2nd quintile: 18.04–65.92	1.12 (0.98–1.27)	1.14 (0.99–1.31)	0.99 (0.78–1.25)
3rd quintile: 65.93–398.32	0.94 (0.82–1.08)	0.99 (0.86–1.15)	0.80 (0.59–1.07)
4th quintile: 398.33–1.847.02	0.99 (0.86–1.13)	1.05 (0.90–1.21)	0.77 (0.55–1.08)
5th quintile: 1.847.03–5.337.45	1.23 (1.06–1.42)	1.10 (0.94–1.29)	0.87 (0.57–1.33)
Control variables			
Individual characteristics			
Sex			
Female		1.20 (1.09–1.33)	1.20 (1.09–1.32)
Male		Ref	Ref
Age			
18–24 years old		2.01 (1.43–2.84)	1.95 (1.38–2.75)
25–34		1.74 (1.35–2.24)	1.66 (1.29–2.15)
35–44		1.76 (1.39–2.23)	1.71 (1.35–2.18)
45–54		1.40 (1.13–1.72)	1.37 (1.11–1.69)
55–64		1.37 (1.17–1.60)	1.34 (1.14–1.57)
65+		Ref	Ref
Highest level of education completed			
None		1.68 (1.42–1.98)	1.61 (1.36–1.90)
Secondary/professional		1.31 (1.15–1.48)	1.27 (1.12–1.44)
Collegial		1.14 (0.99–1.31)	1.12 (0.97–1.29)
University		Ref	Ref
Employment			
Full-time		1.15 (0.97–1.37)	1.14 (0.96–1.35)
Part-time		1.34 (1.09–1.64)	1.31 (1.06–1.62)
Unemployed		1.60 (1.31–1.97)	1.58 (1.29–1.94)
Retired/semiretired		Ref	Ref
Household composition			
Single		1.51 (1.27–1.78)	1.50 (1.26–1.78)
Single with children		1.67 (1.30–2.16)	1.65 (1.28–2.13)
Couple or other adult without children		1.05 (0.90–1.23)	1.05 (0.90–1.23)
Couple or other adult with children		Ref	Ref
Chronic physical illness			
None		Ref	Ref
One		1.04 (0.93–1.17)	1.05 (0.93–1.18)
Two or more		1.14 (0.98–1.32)	1.14 (0.98–1.33)
Perceived health			
Excellent or really good		Ref	Ref
Good		1.80 (1.60–2.01)	1.78 (1.59–2.00)
Fair or bad		3.21 (2.78–3.72)	3.13 (2.70–3.63)
Environmental characteristics			
Lack of trees in the neighbourhood			
Very big or quite big problem			1.67 (1.40–1.99)
Small problem			1.13 (0.98–1.30)
No problem			Ref

Table 2 (continued)

	Model 1 (density)	Model 2 (density + individual)	Model 3 (density + individual + environment)
Social deprivation			
1st quintile (least deprived)			Ref
2nd quintile			0.97 (0.80–1.18)
3rd quintile			0.97 (0.77–1.22)
4th quintile			0.81 (0.62–1.06)
5th quintile (most deprived)			0.84 (0.60–1.19)
Intersection density			
1st quintile			Ref
2nd quintile			0.84 (0.65–1.08)
3rd quintile			1.17 (0.85–1.61)
4th quintile			1.26 (0.88–1.81)
5th quintile			1.21 (0.78–1.87)
Vegetation index			
1st quintile			1.07 (0.73–1.56)
2nd quintile			1.13 (0.83–1.54)
3rd quintile			1.08 (0.84–1.40)
4th quintile			1.09 (0.90–1.31)
5th quintile			Ref
Land use mix			
1st quintile			Ref
2nd quintile			1.12 (0.92–1.36)
3rd quintile			1.09 (0.90–1.33)
4th quintile			1.08 (0.89–1.32)
5th quintile			1.17 (0.92–1.49)

Behavioural variables were not included in the final regression model because none of these variables respected the last step of Baron and Kenny's method, which means that they were not considered as mediating variables. Thus, by adjusting for these variables (model 3), the relationship between residential density (5th quintile vs. 1st quintile) and distress decreased more considerably (OR 0.87; 95% CI: 0.57–1.33). Young adults (18–24 years old) had an OR almost two times higher than that of the adults 65+ years old (OR 1.95; 95% CI: 1.38–2.75). Having a low socio-economic situation (no diploma, no job) was also associated with distress, as was being a single parent (OR 1.65; 95% CI: 1.28–2.13) or being single (OR 1.50; 95% CI: 1.26–1.78). In addition, bad perceived health was more strongly associated with distress, with an OR of 3.13 (95% CI: 2.70–3.63). Finally, the only environmental variable significantly associated with distress was the lack of trees in the neighbourhood (OR 1.67; 95% CI: 1.40–1.99).

Discussion

The objective of this study was to measure the association between urban and rural places of residence and distress while

considering the roles of individual and environmental variables. First, in line with the literature, descriptive analyses (Table 1) showed that some groups of populations in the Eastern Townships were more at risk than others of experiencing distress. Indeed, it is widely known that women, young people, and those with a low socio-economic status are more affected by distress (Price et al. 2008; Drapeau et al. 2011). The results also suggested that retired people displayed less distress than others. This can be explained by the fact that retired people being older contributed to reducing the level of distress in this category. It is interesting to see that full-time work may have a protective role. Single-parent families represented a class of individuals with the most distress, which was also found in a national pan-Canada survey (Wade et al. 2011). Regarding chronic physical illness and bad perceived health, people in these two categories were found to report more distress, which corresponds to what was found in the Canadian Community Health Survey—Mental Health 2012 (Baraldi et al. 2015). For environmental variables, areas most disadvantaged materially and socially were communities in which distress was greatest. These results were not surprising because the material component of disadvantage includes indicators of employment, schooling, and income, and the social

component includes indicators of marital status and family structure (Pampalon and Raymond 2003), whereas all of these factors were associated with distress at the individual level.

The results of logistic regression analyses (Table 2) showed, first, a significant unadjusted estimate for the last density quintile (central communities in Sherbrooke, Granby, and Magog). The other quintiles were not statistically significant, which could possibly mean that after reaching a certain residential density, the effect on people's distress is notable. Therefore, those living in the densest communities (quintile 5) had 1.23 times the odds of presenting distress compared with those living in the first quintile. Next, adjusting for the participants' socio-demographic variables (model 2), the relationship was no longer significant, but clinically, the change was not important enough (OR 1.23 to 1.10), which means that individual characteristics did not seem to explain the link between urbanization and distress and that there are other possible factors that can explain it. These results were in line with those from the Dhingra et al. (2009) study showing that distress was 22% (OR 1.22; 95% CI 1.09–1.36) higher in urban areas than in rural areas and that socio-demographic characteristics did not explain this relationship. Additionally, in the meta-analysis of studies conducted by Peen et al. (2010), the most urban areas were more at risk of mood and anxiety disorders than rural areas.

By including all individual and the five environmental variables that met the four steps by Baron and Kenny (1986) in the final regression model, while respecting the conceptual model's logic, the positive relationship between density and distress decreased considerably. Given that the effect size was not big to start with (OR 1.23), its decrease was greater once the environmental variables were taken into account (OR 0.87). The variable with the largest OR was perceived health, indicating that those perceiving their health as bad had 3.13 times the odds of presenting distress compared with those considering their health as excellent or really good. The only significant environmental variable was the subjective variable regarding the lack of trees in the neighbourhood. These results indicated that one's perception can in fact be more important than objective variables. It is possible to say that environmental characteristics were responsible for a larger reduction in the association between residential density and distress. The minor role of individual characteristics compared with that of environmental characteristics (model 2 vs. model 3) suggests a contextual effect that is greater than the compositional effect. Some characteristics of urban environment could explain the relationship between urbanization and distress in the Eastern Townships.

This study presented limitations that required caution when interpreting results. First, the cross-sectional research design did not lead to a conclusion that there were causal links, but only the presence or absence of associations. As this study was a secondary analysis, important determinants of distress

(personal and social factors) were not available; therefore, the model was not complete. In addition, because the survey was by telephone, there was a possible selection bias of respondents since the people reached excluded those without telephones and those who were homeless, which may have led the study to underestimate the relationship between residential density and distress in the Eastern Townships. A misclassification bias was also possible because information about the origins of the core items of the study was not available. Furthermore, the results were not generalizable to another population because the quintiles of residential density were specific to the Eastern Townships. It would also be relevant for future research to consider how long respondents had lived at the address provided during the interview.

This study also presented a number of positive points. The use of a well-established scale to measure the outcome is to be noted. Additionally, to our knowledge, it was the first study that simultaneously examined the roles of individual and environmental variables (subjective and objective) in the relationship between residential density and distress in a Canadian context. It would be interesting to take this research further because it is possible to act on these environmental factors, and despite the missing determinants (personal and social), the results still suggested that the environment should be studied more and taken into consideration in the future. Finally, the large sample size and representativeness increased the statistical power.

Conclusion

This study contributes to the advancement of knowledge on distress and its association with urbanization in a Canadian context. It enables us to better understand the mechanism that explains its association with urbanization by controlling for individual characteristics and environmental variables. Finally, the potential mediating role of environmental variables was studied and taken into consideration, which has previously not been done in the literature on this subject, which allowed us to find that one's perception (e.g., lack of trees in the neighbourhood) can in fact be more important than objective variables.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethics approval and consent to participate This was a secondary analysis of 2014–2015 ETPHS data, a cross-sectional study led by the Eastern Townships Public Health Department. This study was approved by the research ethics board of the *Centre de santé et de services sociaux—Institut universitaire de gériatrie de Sherbrooke* (CSSS-IUGS), now known as the *CIUSSS de l'Estrie-CHUS* (2014-460).

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