

Title: Moving beyond the residential neighbourhood to explore social inequalities in exposure to area-level disadvantage: Results from the Interdisciplinary Study on Inequalities in Smoking

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Research highlights:

- We examined social inequalities in exposure to disadvantage in the residential area and non-residential activity space;
- Participants in low and middle educational categories lived and conducted activities in more disadvantaged areas than their university counterparts;
- Accounting for mobility exacerbated inequalities in exposure to area-level deprivation for the lower educational category, but attenuated inequalities for the middle category;
- Residential and non-residential contexts are relevant to the study of social inequalities in health-relevant exposure.

Abstract

The focus, in place and health research, on a single, residential, context overlooks the fact that individuals are mobile and experience other settings in the course of their daily activities. Socio-economic characteristics are associated with activity patterns, as well as with the quality of places where certain groups conduct activities, i.e. their non-residential activity space. Examining how measures of exposure to resources, and inequalities thereof, compare between residential and non-residential contexts is required. Baseline data from 1,890 young adults (18 to 25 years-old) participating in the Interdisciplinary Study of Inequalities in Smoking, Montreal, Canada (2011-2012), were analyzed. Socio-demographic and activity location data were collected using a validated, self-administered questionnaire. Area-level material deprivation was measured within 500-meter road-network buffer zones around participants' residential and activity locations. Deprivation scores in the residential area and non-residential activity space were compared between social groups. Multivariate linear regression was used to estimate associations between individual- and area-level characteristics and non-residential activity space deprivation, and to explore whether these characteristics attenuated the education-deprivation association. Participants in low educational categories lived and conducted activities in more disadvantaged areas than university students/graduates. Educational inequalities in exposure to area-level deprivation were larger in the non-residential activity space than in the residential area for the least educated, but smaller for the intermediate group. Adjusting for selected covariates such as transportation resources and residential deprivation did not significantly attenuate the education-deprivation associations. Results support the existence of social isolation in residential areas and activity locations, whereby less educated individuals tend to be confined to more disadvantaged areas than their more educated counterparts. They also highlight the relevance of investigating both residential and non-residential contexts when studying inequalities in health-relevant exposures.

Keywords: Canada; activity space; context; social inequality in health; mobility; neighborhood; residential trap; young adult

Introduction

Place and health inequality researchers have generally been concerned with documenting the variable distribution of environmental conditions, such as disadvantage or health-relevant resources, across areas, and examining their association with the health of people who live there. Most studies have investigated the residential neighbourhood as the sole geographical context of interest (Chaix, 2009; Diez Roux & Mair, 2010; Pickett & Pearl, 2001; Riva, Gauvin, & Barnett, 2007; Shareck & Frohlich, 2013). Because of this, studies have been criticized for falling into the “residential trap” since individuals’ mobility across space, and their experience of other daily life settings such as where they study, work, play, or socialize, are overlooked (Chaix, Merlo, Evans, Leal, & Havard, 2009; Kwan, 2009).

Indeed, people are not bound to their residential neighbourhood: they move in and out of it in the course of their daily activities, and may encounter different types and levels of resources in their activity locations compared to their residential neighbourhood (Basta, Richmond, & Wiebe, 2010; Hurvitz & Moudon, 2012; Inagami, Cohen, & Finch, 2007; Kestens, Lebel, Daniel, Theriault, & Pampalon, 2010; Setton, Marshall, Brauer, Lundquist, Hystad et al., 2011; Zenk, Schulz, Matthews, Odoms-Young, Wilbur et al., 2011). Resources experienced in activity settings may in turn influence health (Inagami et al., 2007; Kestens, Lebel, Chaix, Clary, Daniel et al., 2012; Mason, 2010; Setton et al., 2011; Vallee, Cadot, Grillo, Parizot, & Chauvin, 2010; Vallee, Cadot, Roustit, Parizot, & Chauvin, 2011; Vallee & Chauvin, 2012; Zenk et al., 2011). For instance, in the L.A. Fans Study, USA, Inagami *et al.* (2007) found that conducting activities in areas which were more affluent than one’s residential neighbourhood was associated with better self-rated health than experiencing activity settings of similar disadvantage than one’s neighbourhood (Inagami et al., 2007).

Most importantly, mobility and activity patterns may vary with personal characteristics such as age, gender, and various indicators of socio-economic status (SES) such as income or education (Camarero & Oliva, 2008; Guest & Lee, 1984; Kwan, 2000; Macintyre & Ellaway, 1998; Morency, Paez, Roorda, Mercado, & Farber, 2011; Paez, Gertes Mercado, Farber, Morency, & Roorda, 2010; Schönfelder & Axhausen, 2003; Wang, Li, & Chai, 2012). Adulthood generally comes with increasing mobility and spatial extent (Morency et al., 2011), while lower SES has been found to be associated with shorter trip distances than higher SES (Paez et al., 2010). These socially-patterned characteristics may also influence the type and quality of places one experiences in one's daily activities (Inagami et al., 2007; Krivo, Washington, Peterson, Browning, Calder et al., 2013; Wang et al., 2012). All else being equal, mobility and the conduct of regular activities may allow privileged residents to “escape” their disadvantaged neighbourhood, while others may be exposed to activity settings of higher disadvantage, or to resources of lower quality, than where they live. Consequently, the exclusive focus on the residential area likely provides an incomplete picture of inequalities, between social groups, in contextual exposure to area-level disadvantage or health-relevant resources.

If mobility allowed for perfect social mixing to occur across more or less affluent areas, the daily conduct of activities outside the home would contribute to flattening differentials in contextual exposures between social groups. Alternatively, it has been suggested that residential social isolation, whereby lower socio-economic groups tend to live in deprived and less well resourced areas, and higher SES groups in affluent neighbourhoods, might extend to the places where they conduct daily activities (Krivo et al., 2013; Wang et al., 2012). In such a case, mobility would leave inequalities based on residential exposure to deprivation and resources untouched, or it might potentially exacerbate them (Palmer, Espenshade, Bartumeus, Chung, Ozgencil et al.,

2013). In fact, while in theory mobility may give people the freedom to access all parts, disadvantaged or not, of a city, in practice, lower socio-economic groups may have a lesser capability than their higher SES counterparts to access and use resources in more advantaged areas (Fitzpatrick & La Gory, 2000; Hägerstrand, 1970). A conservative hypothesis lies in between these two, namely that accounting for mobility leads to a reduction in social inequalities in exposure, without completely eliminating the gradient (Ellis, Wright, & Parks, 2004).

Whether inequalities in exposure measured in the residential neighbourhood are reduced, left untouched or augmented when mobility is considered remains elusive. Few studies have looked at social isolation beyond the residential neighbourhood (Fitzpatrick & La Gory, 2000; Krivo et al., 2013; Kwan, 2013), and those which have most often been concerned with racial segregation (Ellis et al., 2004; Palmer et al., 2013; Wang et al., 2012; Wong & Shaw, 2011), rather than with social differentials in exposure to area-level disadvantage or other health-influencing environmental conditions (Krivo et al., 2013; Kwan, 2013).

Objectives

We explore the impact that mobility and the conduct of regular activities have on exposure to area-level disadvantage, and inequalities thereof, in a sample of young adults. We focus on area-level disadvantage since it has consistently been found to be associated with residents' health-detering practices such as smoking (Chow, Lock, Teo, Subramanian, McKee et al., 2009; Ellaway & Macintyre, 2009; Frohlich, Potvin, Gauvin, & Chabot, 2002) and with health outcomes such as poor self-rated health (Pickett & Pearl, 2001; Riva et al., 2007) and cardio-vascular diseases (Chaix, 2009; Chow et al., 2009; Riva et al., 2007). We compare exposure to disadvantage measured in the more traditional, residential area, and in the non-residential activity space. The latter is

operationalized as the subset of regular activity locations excluding the home. Activity spaces have been used as a proxy for spatial mobility (Sherman, Spencer, Preisser, Gesler, & Arcury, 2005) and they have been described as being influenced by people's social position (Golledge & Stimson, 1997 p.282).

This paper's specific objectives were:

- (1) To assess whether there were social inequalities in exposure to area-level deprivation measured in the residential neighbourhood and non-residential activity space;
- (2) To compare social inequalities observed in residential neighbourhood and non-residential activity space deprivation;
- (3) To assess whether selected individual- and residential-level characteristics attenuate the association between participants' SES and deprivation measured in the non-residential activity space.

We hypothesized that (1) there would be inequalities, across participants' SES, in exposure to residential and non-residential deprivation whereby lower SES individuals would live and conduct activities in more disadvantaged areas than their higher SES counterparts; (2) social inequalities would be smaller in the non-residential activity space than in the residential neighbourhood; and (3) adjusting for selected characteristics (eg. individual socio-demographics, residential deprivation) would attenuate the association between SES and non-residential activity space disadvantage.

Methods

Study design and data collection. Between November 2011 and August 2012, 6,020 young adults living in one of the 35 health services catchment areas (CLSC) on the island of Montreal, Canada, were invited to take part in the Interdisciplinary Study on Inequalities in Smoking (ISIS). Eligibility criteria included being between 18 and 25 years-old, being fluent in French or English, and having lived for at least one year at one's current residence. 2,093 young adults completed a questionnaire either online using a secured website (90%), on paper (4.2%) or over the phone with a research assistant (5.8%), in exchange for a 10\$ gift certificate. The final response rate was 37.6%. Ethical approval for this study was obtained from the Research Ethics Committee of the Université de Montréal's Faculty of Medicine.

In the questionnaire, participants provided socio-demographic and health data. An activity location questionnaire was also specifically developed to collect information on respondents' regular activity locations. Participants were asked to report if they regularly conducted any of the following activities: studying, working, grocery shopping, sports or physical activity, leisure activity, and up to two other unspecified places where they regularly spent time. Participants were invited to provide information on the location where the activity usually took place (place name, address, street, closest intersection or landmark, city). The activity location questionnaire had high test-retest reliability with 86.5% overall agreement between information provided at two-week intervals. Convergent validity was also high when comparing questionnaire locations to a continuous GPS track and locations reported through a prompted-recall survey. Questionnaire development and validity are described in more detail elsewhere (Shareck, Kestens, & Gauvin, 2013).

Measures

Defining the residential area and non-residential activity space. Residential and activity locations were cleaned and geocoded. Since geocoding precision is maximized for exact street addresses, these were sought for all activity locations using the Google© search engine. Out of the 8,422 residential and activity locations for which some information was provided, 7.5% were not geocoded for lack of precise information. Latitude and longitude coordinates were obtained for the remaining 7,792 locations using a free geocoder available online which uses the Google Maps© application programming interface (Batch Géocodeur, 2007). Geocoding at the exact address was successful for 97.1% of locations, while for the remaining ones geocoding was performed using the closest intersection (n=136), place name (n=42), closest landmark (n=24), street name (n=23) or postal code (n=1). Data were spatialized in ArcGIS© v.10.1.

For each location, x,y coordinates were used as anchors around which 500-meter road-network buffer zones were created. This distance has previously been used in contextual studies of smoking (Halonen, Kivimaki, Kouvonen, Pentti, Kawachi et al., 2013; Reitzel, Cromley, Li, Cao, Dela Mater et al., 2011) and dietary practices (van der Horst, Timperio, Crawford, Roberts, Brug et al., 2008). Sensitivity analyses were performed using 800-meter road-network buffers. The residential area was defined as the buffer zone centered on participants' residential location, while the non-residential activity space consisted in the combination of buffer zones for all out-of-home activity locations. Each participant was thus situated in two personally-defined contexts: the residential area and the non-residential activity space.

Area-level material deprivation. Area-level deprivation was measured using the material dimension of the Pampalon index specifically developed to characterize multiple deprivation in

Montreal and in Canada. The Pampalon index has been associated with a number of health outcomes such as premature and tobacco-related mortality (Pampalon & Raymond, 2000). The material dimension of this index combines three variables weighted based on factor analysis: education level (proportion of residents aged 15+ without a high school certificate or equivalent), employment to population ratio (proportion of residents aged 15+ who are employed), and mean income (mean after-tax individual income for employed residents aged 15+) (Pampalon & Raymond, 2000).

Deprivation scores were calculated from 2006 Canadian Census data extracted at the dissemination area (DA) scale, the smallest standard administrative unit in Canada (Statistics Canada, 2012). Scores were aggregated within each buffer zone to calculate the buffer-based deprivation score, and weighted proportionally to the population and surface area of the overlap between the buffer zone and DA. Residential deprivation was defined as the deprivation score for the residential buffer zone, while non-residential activity space deprivation was expressed as the mean score across buffers encompassing out-of-home activity locations. Deprivation scores were expressed as continuous variables with higher scores indicating higher deprivation.

Individual socio-economic status. Participants' socio-economic status was operationalized as their educational attainment (i.e. highest level completed, or, for participants who were enrolled in studies at the time of survey, highest level attained), as done elsewhere (Kestila, Koskinen, Martelin, Rahkonen, Pensola et al., 2006). For students, the highest education level attained was imputed based on the level taught at the establishment attended if it were higher than the highest level completed. For example, someone who had obtained a university degree but who was now enrolled in a trade college was attributed "university studies" as her highest level

attained. Three dummy variables were created indicating whether participants had completed or were enrolled in high school education or less, trade school/CEGEP, or university education. CEGEP refers to post-secondary education institutions from which one must graduate before going to University (Statistics Canada, 2008). These categories respectively correspond to ≤ 11 years, 12-13 years and 14+ years of schooling.

Individual- and area-level covariates. Since the main independent variable, educational attainment, partly reflects age, this variable was automatically included in all analyses. Sex, occupational status (not being a student nor employed/being a student (and employed or not)/being employed), transportation resources (having a driver's permit and owning or having access to a car: yes/no), and residential deprivation were also considered covariates since they may correlate with activity space indicators (Kestens et al., 2010; Krivo et al., 2013; Morency et al., 2011; Paez et al., 2010; Schönfelder & Axhausen, 2003; Zenk et al., 2011). For instance, having a driver's permit and a car has been shown to be associated with visiting areas of lower disadvantage than one's residential neighbourhood (Krivo et al., 2013).

Data analysis

We assessed variation in individual characteristics as well as deprivation in the residential area and non-residential activity space across education levels using descriptive statistics and t-tests, chi-square tests and analyses of variance. Means, standard deviations and p-values are reported. Bi-variate Pearson coefficients were used to examine the correlation between deprivation measures in residential and non-residential contexts.

We estimated age-adjusted means and 95% confidence intervals for each educational group, accounting for potential non-independence of observations given the nested sampling frame of the ISIS study (with between 35 and 71 participants nested in each CLSC catchment area). To explore educational inequalities in exposure to area-level deprivation we computed rate differences, for each context definition, by subtracting mean age-adjusted exposure among university graduates/students from mean age-adjusted exposure among lower educational categories. The rate difference is a measure of absolute inequality which has been used to compare disease prevalence between groups (Harper & Lynch, 2005). We also compared rate differences across context definitions for each educational group to explore whether inequalities in residential deprivation were reduced, left untouched or augmented after considering mobility.

We used multivariate linear regression to estimate the crude and adjusted association between educational attainment and non-residential activity space deprivation. Generalized estimating equation models with an exchangeable correlation matrix were fitted to account for clustering within CLSC areas (Hanley, 2003). Covariates which were statistically significantly associated with education and non-residential activity space deprivation in bi-variate analyses were included in models. We also tested two-way interactions between education and (i) occupational status, (ii) age, and (iii) residential deprivation. We estimated P for trend for interaction terms; if the latter were found to be statistically significant ($P < 0.001$), the model including interaction terms was presented.

Four models were successively built: a bi-variate model of the association between educational attainment and non-residential activity space deprivation (model A); a model adjusting for individual-level covariates (model B); a model further controlling for residential deprivation

score (model C); and a full model including interaction terms (model D). Unstandardized beta coefficients and 95% confidence intervals are presented. Coefficients refer to the increase or decrease in deprivation scores associated with a given category compared to the reference group (for categorical variables), or with a one-unit increase in continuous variables. Analyses were performed with SPSS© v.20.0.

Results

Of the 2,093 young adults who completed the questionnaire, 37 were excluded because they had their main work or study place outside the Greater Montreal Metropolitan Region. This latter criterion was established in order for the sample to represent as close as possible people who experience the study territory, Montreal, on a daily basis rather than those who spend most of their time working or studying outside of it.

The remaining 2,056 participants were considered for inclusion in the present analyses. Residential deprivation scores were missing for two participants and 159 did not have deprivation information for their non-residential activity space (73 had provided no information on activity locations, 32 only conducted activities at home, 26 had provided activity location information which could not be geocoded, and for 28 people who conducted activities both in and outside their home, their sole geocoded activity location was their home). An additional 5 participants had missing data for the main independent variable (educational attainment). Excluded participants were more likely to be men, to belong in the lowest educational category, and to be neither in education nor in employment (data not shown).

The final sample for analysis consisted of 1,890 young adults with complete data and is described in Table 1. The sample was 57.7% female with a mean age of 21.5 years (SD: 2.3 years). Participants were relatively well educated, although almost 15% were in the lowest educational category, i.e. high school students/graduates or lower. There was an educational gradient in activity-related characteristics, with the number of activities reported and the number of activities conducted outside the home increasing as education level increased. Mean deprivation scores in the residential area and non-residential activity space were statistically significantly different across educational groups ($P < 0.001$). Participants from the high school or less and the trade school/CEGEP groups were more likely to live and conduct activities in areas of similar (dis)advantage, with coefficients of 0.417 and 0.360 ($P < 0.001$) respectively, compared to university graduates/students ($r = 0.260$, $P < 0.001$) (Table 1).

Table 1: Individual- and area-level characteristics for 1,890 participants from the ISIS Study

	Complete sample (n=1,890)	High school or less (n=275;14.6%)	Trade school/ CEGEP (n=743;39.3%)	University (n=872; 46.1%)	<i>P</i> -value ^a
Individual characteristics					
Sex (female), % (n)	57.7 (1,090)	47.3 (130)	57.6 (428)	61.0 (532)	0.000
Age, mean (SD) ^b	21.5 (2.3)	21.2 (2.4)	20.5 (2.3)	22.4 (1.9)	0.000
Occupational status, % (n)					
Not in education and not employed	4.4 (83)	16.7 (46)	2.3 (17)	2.3 (20)	
Student (and employed or not)	73.8 (1,395)	34.5 (95)	77.8 (578)	82.8 (722)	0.000
Employed	21.8 (412)	48.7 (134)	19.9 (148)	14.9 (130)	
Has driver's license and access to a car					
Yes, % (n)	63.7 (1,203)	41.8 (115)	59.8 (444)	73.9 (644)	0.000
Activity-related characteristics					
Number of reported activities					
Mean (SD)	3.19 (1.44)	2.92 (1.39)	3.00 (1.35)	3.43 (1.49)	0.000
Min, max	1,9	1,7	1,7	1,9	
Number of out-of-home activity locations					
Mean (SD)	2.73 (1.36)	2.47 (1.34)	2.56 (1.28)	2.96 (1.40)	0.000
Min, max	1,9	1,7	1,7	1,9	
Area-level deprivation					
Residential deprivation					
Mean (SD)	-0.003 (0.040)	0.009 (0.035)	-0.000 (0.039)	-0.010 (0.040)	0.000
Min, max	-0.166, 0.107	-0.144, 0.101	-0.121, 0.105	-0.166, 0.107	
Range	0.274	0.245	0.226	0.274	
Non-residential deprivation					
Mean (SD)	-0.013 (0.029)	0.002 (0.031)	-0.011 (0.028)	-0.018 (0.028)	0.000
Min, max	-0.129, 0.097	-0.129, 0.097	-0.104, 0.085	-0.103, 0.087	
Range	0.226	0.227	0.189	0.189	
Correlation between residential and non-residential activity space deprivation scores	0.346 (p=0.000)	0.417 (p=0.000)	0.360 (p=0.000)	0.260 (p=0.000)	

^a *P*-value for the difference across educational groups

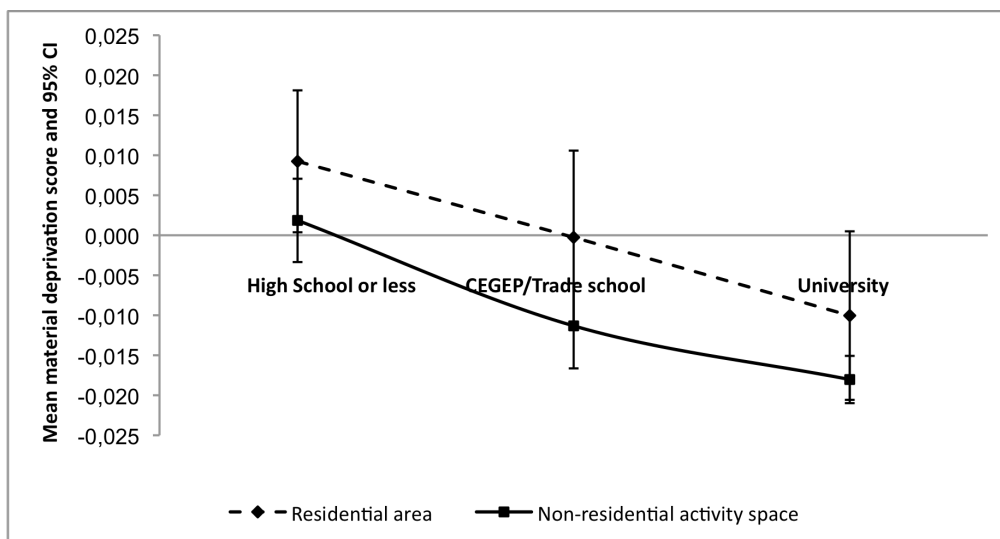
^b SD: Standard deviation

Figure 1 depicts mean age-adjusted deprivation scores in the residential area and non-residential activity space for each educational category along with 95% confidence intervals.

Participants from all three educational groups conducted activities in areas that were on average

more advantaged than their residential neighbourhood. A gradient was apparent in both the residential area (dashed line) and non-residential activity space (solid line): high school and trade school/CEGEP students/graduates lived and conducted activities in areas of higher disadvantage compared to their university counterparts (Figure 1).

Figure 1: Mean age-adjusted deprivation scores and 95% confidence intervals (CI) in the residential area and non-residential activity space by education level



Rate differences, i.e. the educational difference in age-adjusted mean deprivation scores between lower educational categories and university students/graduates, are shown in Table 2. The rate difference for exposure to deprivation in the non-residential activity space was slightly larger than in the residential area for high school students/graduates (0.019 and 0.020 respectively). For trade school/CEGEP students/graduates, the rate difference in the non-residential activity space was smaller than in the residential area (0.007 and 0.010 respectively). This translated, respectively, in an increase in educational differences in exposure to deprivation for participants

with a high school education or less, and in a decrease in differences for the trade school/CEGEP category, once mobility was taken into account (Table 2).

Table 2: Comparison of age-adjusted mean deprivation scores in the residential area and non-residential activity space

	Residential area		Non-residential activity space	
	Adjusted mean (95% CI) ^a	Rate difference ^b	Adjusted mean (95% CI)	Rate difference
High school or less	0.009 (0.000, 0.018)	0.019	0.002 (-0.003, 0.007)	0.020
Trade school/CEGEP	0.000 (-0.011, 0.011)	0.010	-0.011 (-0.017, -0.006)	0.007
University	-0.010 (-0.021, 0.000)	Ref.	-0.018 (-0.021, -0.015)	Ref.

^a CI: confidence interval

^b $\text{Mean}_{\text{lower educational group}} - \text{Mean}_{\text{University students/graduates}}$

Are educational inequalities in non-residential activity space deprivation still apparent after accounting for individual- and area-level characteristics? To answer this question, results from multivariate linear regression models are presented in Table 3.

Table 3: Association between individual- and area-level characteristics and non-residential deprivation score among 1,890 participants in the ISIS study

	Model A	Model B	Model C	Model D
	b (95% CI) ^a	b (95% CI)	b (95% CI)	b (95% CI)
Individual-level variables				
Education level				
High school or less	0.017 (0.013, 0.021)	0.016 (0.011, 0.021)	0.014 (0.008, 0.019)	0.007 (-0.001, 0.016)
Trade school/CEGEP	0.005 (0.002, 0.009)	0.008 (0.004, 0.012)	0.006 (0.002, 0.010)	0.001 (-0.007, 0.009)
University	Ref.	Ref.	Ref.	Ref.
Age		0.001 (0.001, 0.002)	0.001 (0.000, 0.002)	0.001 (0.000, 0.002)
Sex				
Women		0.003 (0.000, 0.006)	0.002 (-0.001, 0.005)	0.002 (-0.001, 0.005)
Men		Ref.	Ref.	Ref.
Occupational status				
Not in education nor employment (NEET)		0.012 (0.007, 0.017)	0.012 (0.007, 0.017)	0.017 (0.002, 0.032)
In education		-0.001 (-0.005, 0.003)	-0.002 (-0.006, 0.002)	-0.006 (-0.014, 0.001)
In employment		Ref.	Ref.	Ref.
Transportation resources				
Driver's license and car (yes)		-0.001 (-0.004, 0.001)	-0.001 (-0.003, 0.002)	0.000 (-0.003, 0.002)
Driver's license and car (no)		Ref.	Ref.	Ref.
Area-level variables				
Residential deprivation			0.195 (0.161, 0.229)	0.155 (0.112, 0.197)
Interactions^c				
High school*NEET				-0.006 (-0.024, 0.012)
High school*In education				0.010 (0.002, 0.019)
Trade school/ CEGEP*NEET				-0.009 (-0.029, 0.012)
Trade school/ CEGEP*In education				0.007 (-0.002, 0.016)
High school* Residential deprivation				0.191 (0.090, 0.293)
Trade school/CEGEP* Residential deprivation				0.046 (-0.030, 0.123)

^a Unstandardized beta coefficient and 95% confidence interval; ^b The education*age interaction was not statistically significant. Statistically significant coefficients are in bold ($P < 0.05$).

The unadjusted model (model A) confirmed descriptive results, namely that participants from the high school or less and the trade school/CEGEP groups conducted activities in more deprived areas than university students/graduates, as suggested by beta coefficients of 0.017 (0.013, 0.021) and 0.005 (0.002, 0.009). Adjusting for individual-level covariates slightly increased the association between being a trade school or CEGEP student/graduate and non-residential activity

space deprivation. Older participants and those not in school nor employed conducted activities in more disadvantaged areas than younger and employed participants (model B).

Further controlling for residential deprivation (model C) slightly attenuated coefficients for each education level, which nonetheless remained statistically significant (coefficients of 0.014 and 0.006, $P < 0.001$). All else being equal, women, older participants, and those who were neither studying nor employed conducted activities in more disadvantaged areas, while being a student was associated with a lower disadvantage level in the non-residential activity space than being employed. Residential deprivation was associated with deprivation in the non-residential activity space (coefficient of 0.195, $P < 0.001$).

Positive interaction terms in the final model (model D) suggested that participants who were high school students at the time of survey conducted activities in more deprived areas than other groups. Residing in a deprived area reinforced the association between being in a low educational category and non-residential activity space disadvantage. In other words, the least educated who resided in disadvantaged areas were doubly disadvantaged when it came to the area-level deprivation they experienced in their non-residential activity space.

Discussion

In this paper we compared measures of area-level material deprivation in the residential area and the non-residential activity space. We explored if there were educational gradients in exposure measured in each definition of context and how they differed in amplitude. We also investigated whether adjusting for selected individual- and area-level variables attenuated the association between education and non-residential activity space disadvantage.

Several studies have previously compared measures of exposure to disadvantage and other health-influencing environmental conditions between residential and activity space contexts (Basta et al., 2010; Ellis et al., 2004; Hurvitz & Moudon, 2012; Kestens et al., 2010; Krivo et al., 2013; Palmer et al., 2013; Wang et al., 2012; Wong & Shaw, 2011; Zenk et al., 2011). Others have investigated the association between context and health while considering people's experience of multiple settings (Inagami et al., 2007; Kestens et al., 2012; Lebel, Kestens, Pampalon, Theriault, Daniel et al., 2012; Mason, 2010; Palmer et al., 2013; Vallee et al., 2010; Vallee et al., 2011; Vallee & Chauvin, 2012; Zenk et al., 2011). However, unavailability of data on individuals' socio-economic characteristics (Kestens et al., 2010) or the lack of variability in socio-economic status (Zenk et al., 2011) have generally hampered the exploration of social inequalities in activity space exposures. Our study thus fills an important gap regarding the social patterning of contextual exposures beyond the residential neighbourhood. It is one of the few that has aimed to quantify the social (in this case educational) inequalities in exposure to non-residential activity space deprivation (Krivo et al., 2013).

Key findings

In our study, we found low to medium correlations between deprivation scores in the residential area and non-residential activity space, a finding in line with other studies, which have focused on fast-food outlet density and park land use (Hurvitz & Moudon, 2012; Zenk et al., 2011). Correlations were slightly stronger among participants from the high school or less and the trade school/CEGEP categories compared to university students/graduates, suggesting that the former two groups tended to live and conduct activities in areas of more similar deprivation levels than the latter group. The lower correlation between residential and non-residential activity space deprivation scores among the most educated also suggests that they experienced a more diverse

array of areas characterized by low and high deprivation. The dissimilarity between residential and non-residential environments lends support to the relevance of studying both contexts when documenting social inequalities in exposure to disadvantage and resources, and eventually in health, since none perfectly approximates the other.

In comparing mean deprivation scores in the residential area and non-residential activity space between the highest and lower educational categories, we found that less educated participants lived and conducted activities in more disadvantaged areas than their university counterparts. This finding supports prior studies (Krivo et al., 2013), as well as our first hypothesis, namely that there would be educational inequalities in area-level deprivation in both the residential and non-residential activity space contexts.

We further examined whether mobility and the conduct of regular activities served to reduce, flatten or exacerbate the educational inequalities found in exposure to residential deprivation. All three educational groups experienced, on average, more advantaged places than their residential neighbourhood in the course of their daily activities. However, mobility increased the educational difference in exposure between the most and least educated, but decreased the difference between trade school/CEGEP and university students/graduates. Our second hypothesis was therefore only supported by our results concerning the trade school/CEGEP group. This suggests that the least educated may suffer not only from the double burden of living and conducting activities in disadvantaged areas, but also from being confined to considerably less affluent activity locations than their more educated counterparts. This observation is similar to that of Krivo *et al.* (2013) who found that even when living in similarly disadvantaged neighbourhoods, African Americans and Latinos conducted activities in more disadvantaged areas than Whites

(Krivo et al., 2013). It runs counter to results from a study in Los Angeles in which racial segregation was more pronounced in residential than in work areas for certain racial groups such as Mexican immigrants (Ellis et al., 2004). This latter study however characterized residential and activity locations in terms of their racial composition rather than their disadvantage level, which limits direct comparison with our results.

Using linear regression models, we found that participants who were in the high school or less and trade school/CEGEP categories conducted activities in areas which were more disadvantaged than their higher educational counterparts, even after controlling for such factors as occupational status or transportation resources. These results mirror those of Krivo *et al.* (2013) (Krivo et al., 2013), but are in opposition with a study by Zenk *et al.* (2011) who had found that activity space measures of fast-food outlet density did not differ across age, gender, race/ethnicity and socio-economic position. However, in this latter study low variability in participants' socio-economic characteristics might have prevented the detection of statistically significant associations (Zenk et al., 2011). Inequalities in exposure to health-relevant features and resources in the non-residential activity space may also depend on their spatial distribution. It is therefore possible that findings would differ depending on which contextual exposure is investigated.

Controlling for residential deprivation attenuated the association between education and non-residential activity space deprivation, which nonetheless remained significant. Regardless of their residential neighbourhood deprivation level, participants with a lower educational attainment thus tended to conduct activities in more disadvantaged areas than university students/graduates. These results also imply that non-residential deprivation levels experienced by less educated participants are not entirely attributable to their social and demographic characteristics, and that

residential deprivation level, in itself, does not determine the deprivation level experienced in activity locations. Beyond this main effect, a positive interaction between residential deprivation and being a high school student/graduate was found suggesting that the association between residential and non-residential deprivation was more pronounced among the least educated.

A positive interaction between being in the lowest educational group and being a student was also found, indicating that high school students were more likely to conduct activities in more deprived areas than other groups, including high school graduates. While a thorough examination of this interaction was beyond the scope of this paper, it points towards an increased vulnerability of young adults who are still in school to experience disadvantaged areas in the course of their daily activities. It also highlights the relevance of devising more nuanced composite indicators of young adults' socio-economic status combining, for example, measures of educational attainment and occupational status (Solberg, Asche, Boyle, McCarty, & Thoele, 2007; Yang, Lynch, Schulenberg, Diez Roux, & Raghunathan, 2008).

Making sense of findings. Several hypotheses could help explain the social isolation phenomenon we observed in the study of non-residential activity spaces. A number of socially-patterned individual- and area-level factors may enable or constrain mobility through space as well as influence the quality of places where certain groups conduct regular activities.

For example, the differential distribution of economic capital such as income, across educational groups, could contribute to explaining the inequalities found in this study. The amount of money one has is associated with the types of activities one can engage in and the characteristics of places where these are located (Kestens et al., 2010; Skelton, 2013; Zenk et al., 2011). In the

present study, it could have been that trade school/CEGEP and university students/graduates were more able to disburse money to conduct sports and leisure activities, for example, in places located in more affluent areas that are known to attract people with more economic capital. Conversely, these areas might have been less accessible to people in lower socio-economic groups.

One's social capital and the influence it has on the people and places one associates with could also help shed light on our findings. Where people spend time may depend on where members of their social network live or conduct activities (Matthews, Detwiler, & Burton, 2005). It has been suggested that homophily, i.e. "the principle that a contact between similar people occurs at a higher rate than among dissimilar people" (McPherson, Smith-Lovin, & Cook, 2001 p.416), prevails in most social associations. In our study, lower educational groups may have had family or friends living or conducting activities in more disadvantaged areas compared to more educated participants.

Finally, aspects of the built and social environments may help explain some of the findings. Work and study opportunities available to individuals with lower qualifications may be located in less affluent parts of the city compared to opportunities available to those with higher qualifications (Palmer et al., 2013). This could partly explain why, in our study, the least educated, who were also more likely to be employed, not students, experienced more disadvantaged areas in their daily activities. Also, as originally discussed by Hägerstrand (1970), there may be social constraints which "subsume those general rules, laws, economic barriers, and power relationships that determine who does or does not have access to specific domains at specific times for either purposes" (Pred, 1977 p.208). Certain undisclosed rules may regulate which groups can access certain resources, as well as who may be welcome or not in specific places (Hägerstrand, 1970;

Reynolds, 2013). For instance, young adults of lower education level may not have travelled to affluent neighbourhoods to play sports because they did not feel they belonged there.

Strengths, limitations and methodological notes. An important strength of our study lay in its use of an activity location questionnaire, which had been developed specifically for the study of mobility and health inequalities in young adults. It was previously validated, allowing to collect precise and valid data on the location of regularly performed activities which were relevant to the population under study (Shareck et al., 2013). The sample was also large and included young adults whose educational backgrounds spanned the whole spectrum from low to high attainment. This permitted us to study inequalities across all groups, rather than only focus on differences between the least and most educated. It should, however, be noted that our sample was highly educated. This may be specific to the Montreal context, since a similarly high proportion of highly educated young adults have been reported in a comparable sample of respondents to the Canadian Community Health Survey (2007-2010) (data not shown). This, along with the fairly low response rate (37.7%), may limit the generalizability of our findings.

We were unable to disentangle whether participants' activity locations were deliberately chosen or if they were constrained. We attempted to explore this by performing additional analyses distinguishing between non-discretionary (work and study) and discretionary activities (grocery shopping, sports, leisure and other activities), a classification used as a proxy for “constrained” and “chosen” locations respectively (Hägerstrand, 1972, in (Golledge & Stimson, 1997)). Interestingly, a larger difference between mean exposure to area-level disadvantage among university students/graduates and lower educational groups was found for the discretionary, compared to the non-discretionary, activity space (data not shown). This suggests that confinement of less educated

groups to disadvantaged areas may be more pronounced in discretionary activity locations than non-discretionary ones, and that “chosen” activity locations may drive educational inequalities found in the non-residential activity space. While the present study did not permit us to describe the enabling and constraining factors influencing young adults’ access (or lack thereof) to more or less disadvantaged areas, it is critical that more work be conducted to identify these facilitators and barriers. Promoting the former and eliminating the latter would contribute to providing all educational groups with equal opportunity to access all parts of the city.

Worthy of discussion is also our reliance on young adults’ highest education level attained as a proxy for their socio-economic status. Educational attainment is not always completely established in this age group. We acknowledge that educational attainment only partially reflects young adults’ socio-economic status. However, young adulthood is a transition period marked by many social changes, with people moving out of education, entering the workforce and moving out of the parental home (Pensola & Martikainen, 2004). During this time, other indicators of socio-economic status such as income, occupational class or housing tenure may be even less well established. Commonly used indicators such as parental education or occupation may also provide only imperfect measure of young adults’ own socio-economic status since, as hypothesized by West *et al.* (1997) during youth and young adulthood, people may be developing their own identity and moving away from parental influences including that of their socio-economic background (West, 1997). For these reasons, and since education has previously been used in studies on health inequalities in young adults (Casswell, Pledger, & Hooper, 2003; Glendinning, Love, Hendry, & Shucksmith, 1992; Kestila et al., 2006; Rahkonen, Arber, & Lahelma, 1995), it was deemed the most appropriate proxy for their current social position, knowledge and access to economic and cultural resources, as well as future social attainment (Galobardes, Shaw, Lawlor, Lynch, & Davey

Smith, 2006). In the event of misclassification of participants' highest educational attainment, with less educated participants potentially moving on to higher education, the findings reported here would underestimate inequalities across educational categories. Lower and intermediate groups would in fact comprise a mix of both lower and higher educated individuals, thus biasing point estimates towards the null.

The fact that young adults' education level partly reflects age should finally not be seen as a concern since significant differences in exposure to deprivation between educational groups were found after adjusting for age. We also did not find a significant interaction between education level and age, suggesting that the association between education level and non-residential activity space deprivation did not vary significantly across age groups.

Lastly, methodological notes should be made. We studied area-level disadvantage as a health-relevant exposure *per se*, assuming that material deprivation was fundamentally health-detracting, even though areas that are socio-economically disadvantaged may not be so with regards to other health-relevant conditions (Macintyre, Macdonald, & Ellaway, 2008). In our sample, area-level deprivation was strongly correlated with other Census-derived variables, but less so for features such as tobacco-selling outlets and the density of green space. An inverse correlation was also found between deprivation and crime rates (data not shown). Area-level deprivation may not be the best proxy for all types of health-relevant resources, and more research is therefore needed to uncover whether similar social gradients are found with different environmental exposures.

When performing analyses on spatially-aggregated data, different results may be obtained depending on the zoning scheme and spatial scale used to measure exposure, i.e. the modifiable

areal unit problem (Openshaw, 1984). We performed sensitivity analyses using data aggregated within 800-meter road-network buffer zones and found results to be robust across spatial scales. Educational inequalities in exposure to area-level disadvantage in both the residential neighbourhood and non-residential activity space were still found, even after adjusting for covariates. Accounting for mobility slightly exacerbated the educational difference between both the least and intermediate groups, compared to the most educated (data not shown). This bolsters the importance of performing sensitivity analyses unless one has a clear theoretical justification for choosing a specific buffer size.

Our focus on the *non-residential* activity space automatically led to the exclusion of participants who only conducted activities at home or who had reported too few details on activity locations to allow for successful geocoding. A large proportion of participants excluded for these reasons were from the lowest educational category. This might have led to a misrepresentation of less educated groups' spatial patterns and to an underestimation of the educational gradient in exposure to area-level disadvantage. More research is required to shed light on low-mobility groups who may be at a particular disadvantage when it comes to accessing resources and opportunities (Chaix, Kestens, Perchoux, Karusisi, Merlo et al., 2012; Vallee et al., 2010; Vallee et al., 2011).

Finally, we operationalized the non-residential activity space as a non-contiguous space, without considering the paths linking participants' activity locations. This choice was made in part because the information was not collected from respondents and is not easy to extrapolate from activity locations themselves. As well, the experience one has of the paths linking activity locations is highly dependent on the mode of transportation used to travel (i.e. walking compared to driving). Activity space is also more likely to be polycentric, composed of a combination of daily

life centers, , rather than continuous (Chaix et al., 2012; Vallee & Chauvin, 2012). Considering participants' regular path network in future studies could nonetheless provide a complementary description of people's mobility and experience of space.

Conclusion

Canzler *et al.* (2008) have described mobility through urban space as “an important factor of social differentiation and generator of new forms of inequality” (Canzler, Kaufmann, & Kesselring, 2008 p.6). With this paper, we wished to further this reflection by considering not only mobility *per se* but also the characteristics of activity places, which different educational groups accessed by being mobile. This paper shed light on educational inequalities in young adults' exposure to area-level deprivation in their residential neighbourhood and non-residential activity space. Identifying groups who chronically experience disadvantaged environments, based on their individual and residential characteristics, may help in better target health promotion efforts. Going beyond the residential neighbourhood in assessing inequalities in exposure to environmental conditions and in potential access to a range of resources may also provide evidence of a detrimental impact of the cumulative influence of living and conducting regular activities in disadvantaged areas. Since social inequalities in health may arise from social inequality in exposure and access to health-promoting environments and resources, next steps will be to investigate whether the educational inequalities documented here are associated with inequalities in health.

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