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ORIGINAL PAPER

Evaluating same-source bias in the association between neighbourhood characteristics and depression in a community sample from Toronto, Canada

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Abstract

Background and purpose It is common in prior studies of the influence of neighbourhood characteristics on mental health to use participant-assessed neighbourhood exposures, which can lead to same-source bias since an individual's mental health status may influence their judgement of their neighbourhood. To avoid this potential bias, we evaluated the use of individually assessed neighbourhood exposures to understand how they compare to collectively assessed measures (by aggregating multiple responses within the same neighbourhood). This would increase the validity of the measure by decoupling the neighbourhood measure from an individual's mental health status.

Methods We conducted a stratified-randomised survey of 2411 adults across 87 census tracts in Toronto, Canada (mean of 28 per census tract) to investigate how self-reported (individually assessed) social environmental neighbourhood measures compared to aggregated, collectively assessed, measures for neighbourhood problems/disorder, safety, service quality, and linking, bonding and bridging social capital. The outcome, experience of major depression in the past 12 months, was measured using the Composite International Diagnostic Studies Depression Scale Short Form.

Results (1) Individually assessed neighbourhood problems, (2) low (individually assessed) neighbourhood safety, (3) low (individually assessed) neighbourhood service quality, and (4) low (individually assessed) linking social capital were independently associated with depression (all at least $p < 0.05$). However, when the individually assessed exposures were aggregated over residents in the same neighbourhood, none of them were significantly associated with depression.

Conclusions Our study provides evidence for same-source bias in studies of social environmental determinants of depression that relies on individually assessed neighbourhood measures. We caution future studies from solely relying on individually assessed neighbourhood exposures especially in the study of social environmental influences on mental health outcomes.

Keywords Depression · Neighbourhood · Same-source bias · Urban planning · Social capital

Introduction

Depression is a leading cause of burden in the Global Burden of Disease 1990, 2000, and 2010 studies [1], and it is associated with reduced quality of life and work performance [2], functional disability [3], cardiometabolic [4] and lung diseases [5], and premature mortality [6]. Studies on the determinants of depression have focused on individual risk factors [7] and population-level risk factors including socioeconomic status [8]. It is also been hypothesised that place-based factors, including the physical and social context of residential neighbourhoods, may impact the risk of depression and depressive symptoms [9–13]. Reviews of the evidence linking social and physical neighbourhood characteristics to depression have resulted in mixed findings [9,

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14], and the purpose of our study is to investigate a potential source for mixed findings, namely the common use of participants self-reported neighbourhood data and its potential for same-source bias.

Self-reported neighbourhood data and the problem of same-source bias

Studies of neighbourhood effects on depression are shaped by how neighbourhood characteristics are conceptualised and measured. Data on neighbourhoods can come from secondary sources such as administrative datasets (e.g. national census or a variety of georeferenced databases) or collected from human observers. The data from human observers is either collected directly from study participants (i.e. self-reported data) or trained raters through systematic social observations [15]. While it may be easy to characterise official administrative sources of data as 'objective' and dismiss self-reported data as 'subjective', these two types of measures are intended to capture different dimensions of neighbourhood environments. Typically, secondary data are well-suited for census variables and characterising the built environment such as density of resources, urban form, land use, and transport networks. However, certain neighbourhood characteristics cannot be feasibly collected in routine administrative data (e.g. social cohesion and sense of safety) and commonly come from participant surveys. The use of subjective reports of perceptions of neighbourhood features raises the methodological challenge of same-source bias, especially when studying mental health issues as an outcome. That is, the mental health status of an individual may influence the reported perceptions of the condition of the neighbourhood. In particular, those who have depressive mood have been shown to have a negative cognitive bias when reporting on perceptions [16–18] which might, in turn, lead them to be more likely to report worse neighbourhood conditions than those without symptoms of depression.

One solution to same-source bias is to combine the responses of many residents of the same neighbourhood [19]. Diez-Roux [20] argues that "by averaging over the measurement error in individual responses, this aggregation process may yield a more valid measure of the 'objective' neighbourhood construct of interest" (p. 5). Stafford et al. [21] also noted in their study of neighbourhood social environment on depression that perceptions aggregated over residents in the same neighbourhood are preferred over participants' individual perceptions to avoid same-source bias. However, like many other studies, theirs was not able to make use of aggregated data since "there are insufficient numbers per area to aggregate data in a meaningful way" (p. 898).

Given the number of previous studies that rely on the use of participant self-reported neighbourhood data [10, 21–24], we have designed a unique study to overcome this problem (i.e. by sampling multiple residents per neighbourhood) to investigate how individually assessed neighbourhood measures compares to collectively assessed measures as predictors of individual-level depression. If results between models using individually assessed and collectively assessed measures are vastly different, this may indicate the influence of same-source bias.

The neighbourhood social and physical environment

Studies have investigated the link between depression and the neighbourhood social context including collective efficacy [25], perceived safety [26], social capital [27], and social cohesion [28]. In a review of studies on the effects of neighbourhood social factors on depressive symptoms [9], 11 out of the 14 reviewed studies found that depression was associated with at least one of the following: neighbourhood deprivation, disorder, instability, and social capital. However, effects across studies were inconsistent and three studies within the review reported no significant association between neighbourhood factors and depression. While many studies rely on census data for neighbourhood characteristics such as neighbourhood socioeconomic position [14] and ethnic composition [29], self-reported measures of the neighbourhood social environment are also very common [10, 22–24]. Fewer studies use self-reported data aggregated to the neighbourhood level [19, 30, 31] despite the potential for a more valid measure. Harpham et al. [30], who used social capital data aggregated to the neighbourhood level (i.e. collectively assessed), found no association between social capital (i.e. trust in others or institutions) and depression/anxiety (as measured by the Self-Reporting Questionnaire—20 Items, SRQ20).

Physical characteristics of neighbourhoods have also been examined in relation to depression, including green space [32], neighbourhood resources [33], land use [34], quality of housing [35], neighbourhood services [14], and neighbourhood disorder, i.e. litter, vacant housing, graffiti, etc. [10]. While information on traffic, green space, and specific neighbourhood services is typically available in commercial and public geospatial databases, other physical environmental variables are not routinely collected (such as presence of litter and graffiti) and researchers have drawn on participants' knowledge of their own neighbourhoods. In a prospective study with a 9-month follow-up, Latkin and Curry [10] found that participant self-reported levels of neighbourhood disorder and appearance (i.e. litter, vacant housing, vandalism, etc.) is associated with depressive symptoms. On

the other hand, in a prospective 3-year follow-up study of 998 middle-aged African Americans, Schootman et al. [36] showed no significant association between researcher-rated neighbourhood disorder/appearance (i.e. researcher-rated housing condition, noise, air quality, conditions of streets, sidewalks and yards) and depressive symptoms. While the specific physical environmental variables and time scales are different across the two studies, this raises questions about the validity of findings from Laktin and Curry [10], and whether their findings may have been influenced by same-source bias.

Aim of the study

Based on previous work by Mujahid et al. [19] and Diez-Roux [20], we propose that by averaging over the measurement error in individual responses, the aggregation process may yield a more valid measure of neighbourhood characteristics, since "collectively assessed" reports of neighbourhood exposures are decoupled from individuals' mental health status. While this makes sense at a theoretical level, no previous studies have explicitly compared the performance of self-reported data (i.e. individually assessed) versus collectively assessed measures to capture the extent to which same-source bias might be influencing the associations with depression (where differential results may be evidence of same-source bias). While Araya et al. [37] have previously evaluated the impact of social capital at both individual and neighbourhood-aggregated levels, their study's outcome was limited to general mental health using General Health Questionnaire-12 (GHQ-12) rather than an instrument specifically intended to evaluate depression as an outcome.

In this study, we sought to build on the existing literature by examining the relationship between a wide range of commonly studied social and physical neighbourhood characteristics (i.e. traffic, neighbourhood income, green space, neighbourhood problems, social capital, neighbourhood safety, and neighbourhood service quality) and risk of depression using CIDI as an outcome. The primary purpose of our study was to evaluate the use of individually assessed neighbourhood exposures (as are commonly used in prior studies) to understand how they would hold up after aggregation to the neighbourhood level, which increases the validity of the measure by decoupling the neighbourhood measure from an individual's mental health status. Our study asks the following research questions:

1. Is there an association between neighbourhood characteristics (i.e. neighbourhood problems, neighbourhood safety, neighbourhood services and resources, and social contact) and depression after adjusting for individual-level confounders?
2. Does the association between neighbourhood characteristics and depression differ if we use individually assessed versus aggregated (i.e. collectively assessed) neighbourhood measures?

Methods

Data

The project NEHW (Neighbourhood Effects on Health and Well-being) is a cross-sectional multilevel study designed to examine neighbourhood-level exposures and individual-level health outcomes. The study used a three-stage probability sampling approach. In the first stage, we randomly selected 47 out of the 140 city-delineated neighbourhood planning areas (NPA). In the second stage, we randomly selected 1–2 census tracts (CT) from each of the 47 selected NPA which yield a total of 87 randomly selected CTs. CTs are small, economically and socially homogeneous geographical units that have a population between 2500 and 8000 persons used by Statistics Canada (Statistics Canada). Finally, within each of the 87 CTs, we randomly selected approximately 25 individuals on the basis of four criteria: (1) being a resident of a selected household; (2) being between 25 and 64 years old; (3) able to communicate in English; and, (4) living in the neighbourhood during at least the last 6 months. Survey response rate is 72%, and the final sample size is 2411 individuals. For the purposes of this paper, CTs are used as a proxy for neighbourhoods. While CTs and other administrative boundaries have been criticised as not representing the true neighbourhood boundaries as seen by residents [35], our analysis is restricted to the central city of Toronto rather than the Toronto metropolitan area (see Fig. 1) where CTs are smaller compared to non-urban areas due to high population density of the central city (i.e. 4149.5 persons/km^2 compared to 14.1 persons/km^2 in the rest of the Province of Ontario [38]). Within our sample of 87 CTs, the mean CT size is 1.03 km^2 (SD 0.7). Moreover, within the same CT, the distances between residents are small, i.e. mean distance = 378 m (SD 204 m). Given the high population density, geographically small census tract size, and proximity of residents within the same CT, we have reason to believe that CTs (in the central city of Toronto) represent a shared residential space for residents. Please refer to the study's core paper for more details on study design, sampling/recruitment, and rationale [39]. Data were obtained in face-to-face interviews, and participants were asked to provide a written informed consent at the time of their interview. The study protocol and ethics were approved by the Research Ethics Board at the St. Michael's Hospital (Toronto, Canada).

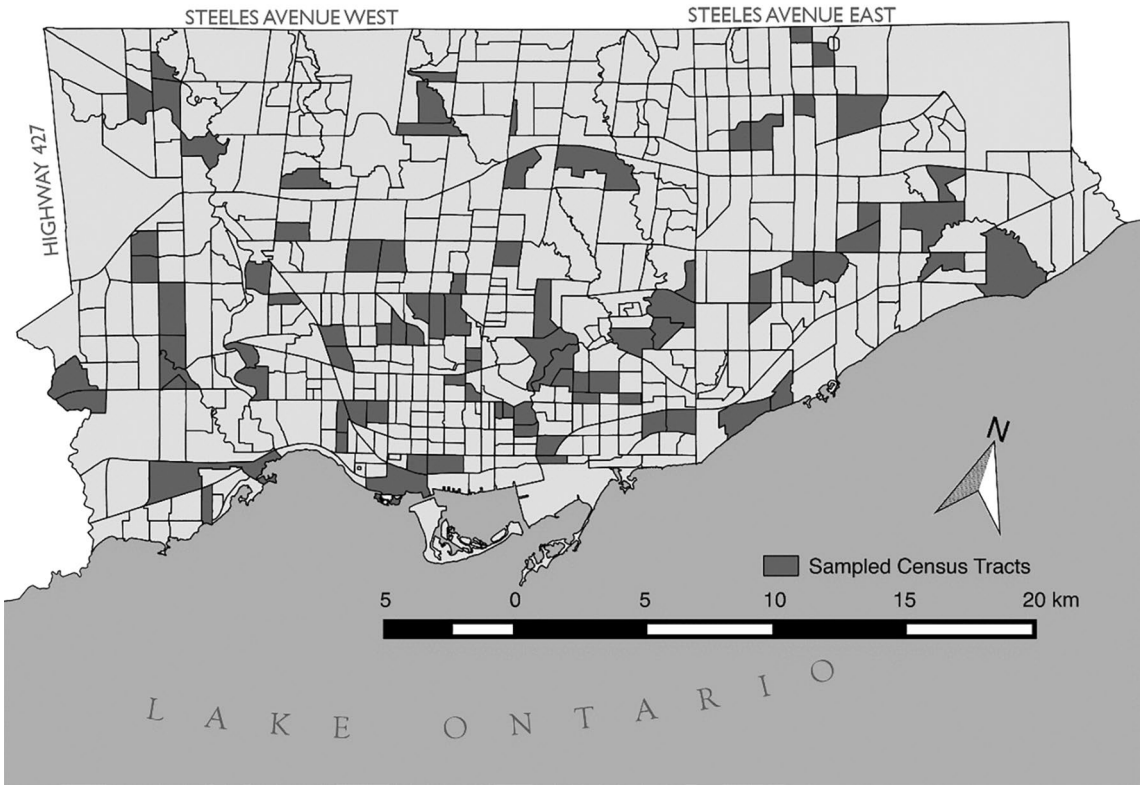

Fig. 1 Map of selected census tracts in our study within the City of Toronto

Outcome

Our outcome of interest is based on whether the participant had been experiencing a major depression episode in the last 12 months. The variety of depression instruments used in prior studies, including the Patient Health Questionnaire (PHQ), and more recently the Composite International Diagnostic Interview Short Form (CIDI), Centre for Epidemiological Studies-Depression (CES-D), may be another reason for mixed findings in the neighbourhoods and depression literature. These instruments varied by symptoms measured, time frames (e.g. last week versus 2 weeks ago), and alignment with results from a diagnostic interview. While the CES-D scale is one of the most commonly used instruments in the studies reviewed above (e.g. CES-D is used in half of all studies in Blair et al.'s [9] comprehensive review of neighbourhood social environments and depression), Fisher et al. [40] found that CES-D is more reflective of general emotional distress rather than clinical depression, and that the CIDI (Composite International Diagnostic Studies Depression Scale) has a higher agreement with the latter.

We screened major depression using the Composite International Diagnostic Interview-Short Form (CIDI-SF) [41]. Based on the World Health Organization CIDI scales (Centers for Disease Control (CDC), the short form was developed using only a small number of screening questions over the 8 major depression disorders. The diagnostic classifications made in the full CIDI can be reproduced with high accuracy with the CIDI-SF scales: overall classification accuracy ranged from a low of 93% for major depressive episode to a high of > 99% for generalised anxiety disorder, and the instrument is validated for use with the general population [41]. The CIDI-SF included standard screening questions to identify symptoms of major depressive episodes that persisted for 2 weeks or longer, are present for most of the day nearly every day and that cause significant distress or impairment. These symptoms included sadness/depressed mood, feelings of discouragement or loss of interest, significant weight gain/loss or appetite disturbance, insomnia or hypersomnia, psychomotor agitation or retardation, fatigue or loss of energy, feelings of worthlessness or excessive guilt, diminished ability to concentrate or think clearly, and recurrent thoughts of death or suicide. Then, we derived a summary scale made up of these symptom questions, which ranged from 0 to 8. The value 0 is assigned when participants responded negatively to all these screening questions; and, higher scores reflect a greater level of depression. Based on a previous study [41], major depression is defined by as the presence of five out of the eight retained symptoms.

Social and physical neighbourhood characteristics

In this study, we sought to build on the existing literature by examining the relation between depression and a wide range of social and physical neighbourhood exposures (i.e. neighbourhood problems, neighbourhood safety, neighbourhood service quality, and social capital). These variables were collected from self-reported survey instruments and were analysed at the individual level and aggregated level. The aggregation approach had been used in applied econometrics [31] and offered a way to include of subjective assessments of neighbourhoods (which are often necessary due to limitations of routinely collected data) while avoiding the problem of same-source bias [20]. All individual-assessed and collectively assessed measures were transformed into z-scores since they were measure by different instruments (with different number of items), and the z-score of these measures would allow us to compare their strength of association with depression across instruments.

Neighbourhood problems (or neighbourhood disorder) were measured using a revised Ross–Mirowsky neighbourhood disorder scale [42]. The original scale includes 14 items related to physical and social disorder in a given neighbourhood, including litter or trash on the sidewalks and street, graffiti on building and walls, rundown sidewalks, or drug dealers hanging out as examples and similar to those used in previous studies [43]. We added additional items that are common problems observed in large urban centres [44] including gang activities, police harassment, prostitution, intoxicated individuals, loitering, unpleasant smells and fumes, pest infestation, and disorderly/misbehaving groups of people (see the modified questionnaire in supplemental materials). Respondents rated the severity of each problem on a scale of zero to four (e.g. "not at all a problem" to "a serious problem"). We computed the Cronbach's Alpha (0.93), indicating a high internal consistency between our survey items. Hence, a mean score was computed by summing up the points obtained for each item and dividing by the number of items, and the mean score was subsequently transformed into a z-score. For collectively assessed neighbourhood problems, the mean of all residents' mean score from the same census tract was computed and transformed into a z-score. For both levels, a higher mean reflects perceptions of greater severity.

Neighbourhood safety was measured using a six-item scale used in two prior studies [19, 45]. Participants were asked the extent to which they worried or someone in the neighbourhood worried (not at all worried to very worried on a five-point scale) about activities: "Walking (or getting) around during the day", "Walking (or getting) around after dark", "Letting children go outside alone at night", "Letting children go outside and play during the day", "Being physically harmed, for example, being beaten up, robbed, or mugged" or "A child being physically harmed, for example, being beaten up, abused, kidnapped or robbed". The Cronbach's Alpha of 0.83 indicated a high level of internal consistency. A mean score was calculated across the six neighbourhood safety items. Then, the mean for individually assessed and collectively assessed neighbourhood safety (computed in the same manner as collectively assessed neighbourhood problems described above) were standardised to z-scores.

Neighbourhood service quality participants were asked about the level of satisfaction of the available services in their neighbourhood. In total, the instrument included 12 items related to public transportation, health care and medical, libraries, housing services, fires services, places of worship, etc. Respondents answered on a scale from zero to four on the basis on their level of satisfaction (e.g. "Strongly dissatisfied" to "Strongly satisfied"). The Cronbach's Alpha was 0.83, indicating high internal consistency. We computed the mean of the scores at the individually assessed and collectively assessed levels (mean of the individual means), and these variables were standardised to a z-score.

Social capital included 'bonding' social capital (trust and reciprocity in close social relationships), 'bridging' social capital (relationships from diverse backgrounds where ties are weak) [46], and 'linking' social capital (trust in authorities) [47]; all have been studied in relation to their link to depression [9]. Bonding social capital is captured by two measures, social cohesion and informal social control. *Social cohesion* is measured using a five-item scale, used in prior studies [48, 49], to capture the frequency of social interactions of the participants. It was measured on the basis of five questions asking how often they speak or see their relatives, friends, and neighbours who live in their neighbourhood. A score was given for each item based on the frequency from zero (not at all in the last 12 months) to four (see or speak every day). The Cronbach's Alpha across the five questions is 0.8. We used Sampson and colleagues' five-item measure of informal social control [48]. Using a Likert scale (i.e. from "very unlikely[=0]" to "very likely[=4]"), Participants were asked how likely neighbours would intervene in cases such as (1) children were skipping school and hanging out on a street corner, (2) children were spray-painting graffiti on a local building, (3) children were showing disrespect to an adult, (4) a fight broke out in front of their house, and (5) the fire station closest to their home was threatened with budget cuts [49]. The Cronbach's Alpha is 0.82, indicating good internal consistency.

Bridging social capital was measured by eight items, drawn from a prior study [50], related to participants' active participation in community social groups such as religious, sports, political groups, etc., and measured by the sum of positive answers up to a total of eight points. *Linking social capital* was measured by eight questions, drawn from a prior

study [51], regarding participants' political activities in the neighbourhood including attending a council meeting, participating in a protest/demonstration, joining together with other neighbours to address a problem, etc., and measured by the sum of positive answers up to a total of 8 points. The Cronbach alpha of these two indicators are 0.8 and 0.81, respectively. For each of the social capital measures (social cohesion, informal social control, bridging, and linking), we computed mean scores at the individually assessed and collectively assessed levels (as described above), and these were standardised into *z*-scores.

To maintain comparability with previous studies of neighbourhood effects on depression which typically control for gender, age, income, and marital status as individual-level covariates [10, 21, 23], we include these sociodemographic covariates in our analyses. Age (as continuous) and gender were included as previous studies showed gender and age differences in depression and on perceived neighbourhood environment [52]. Likewise, we controlled for marital status (married or not married) [53] and household income [54], used as a proxy of household socioeconomic status, for the well documented protective role on depression and individual choices on residential mobility (see Table 1).

Table 1 Sample characteristics

Variables	*N* (weighted)	Population (proportion/mean)	Proportion with depression
Age			
< 30	237	9.9	12.4
30–39	647	27.1	10.1
40–49	767	32.1	10.2
50–59	460	19.3	10.1
60 +	279	11.7	6.5
Male	1159	48.5	7.3
Female	1230	51.5	12.4
Married or common law			
Yes	893	36.0	6.6
No	1497	64.0	15.5
Family income			
0–10,000	190	7.97	9.9
> 10–15,000	84	3.5	15.1
> 15–20,000	59	2.48	20.2
> 20–30,000	227	9.5	17.2
> 30–40,000	176	7.38	15.5
> 40–50,000	187	7.81	10.6
> 50–75,000	449	18.78	7.0
> 75,000 +	1017	42.57	7.5
Individually assessed neighbourhood variables (mean scores)			
Neighbourhood problems	2391	1.0	1.3
Neighbourhood safety	2391	2.9	2.6
Neighbourhood service quality	2391	2.5	2.3
Social cohesion (bonding)	2391	13.5	12.8
Informal group control (bonding)	2391	12.1	11.5
Bridging social capital	2391	1.2	1.2
Linking social capital	2373	20.6	19.9
Neighbourhood problems	87	0.9	1.1
Neighbourhood safety	87	3.0	2.8
Neighbourhood service quality	87	2.7	2.5
Social cohesion (bonding)	87	14.0	13.4
Informal group control (bonding)	87	12.8	12.5
Bridging social capital	87	1.3	1.2
Linking social capital	87	20.8	20.1

Statistical analyses

To begin, we explored the bivariate association between attributes of neighbourhoods and depression over the last 12 months in unadjusted multilevel logistic models for each of the individual-level and neighbourhood-level predictors. To answer our first research question "is there an association between neighbourhood characteristics and depression after adjusting for individual-level confounders?", we examined the association between the neighbourhood characteristics and major depression while adjusting for age, gender, marital status, and household income (models 1–14). A decision was made to include each neighbourhood-level variables in separate models due to multicollinearity.

To answer our second research questions, 'does the association between neighbourhood factors and depression differ if we use individually assessed versus aggregated neighbourhood measures?', separate models were specified to compare results for individually assessed versus collectively assessed (a) neighbourhood problems (models 1 and 2), (b) neighbourhood safety (models 3 and 4), (c) neighbourhood service quality (models 5 and 6), (d) social cohesion (models 7 and 8), (e) informal social control (models 9 and 10), (f) bridging social capital (models 11 and 12), and (g) linking social capital (models 13 and 14).

In order to obtain results that are representative of the population of the City of Toronto, all analyses and descriptive statistics were weighted by post-stratification weights based on the distributions of sex, total household income, household size, immigrant status, and age, obtained from the 2006 Canadian Census data for Toronto [55]. Full description of the weighting process is explained elsewhere [56, 57]. Multilevel logistic regressions with random intercepts were performed using SAS University Education in the GLIMMIX (generalised linear mixed model) procedure. Odds ratios (OR) and 95% confidence intervals were estimated and statistical significance was defined if p values were less than 0.05.

Results

9.16% of our sample were identified with depression. Being over the age of 60, male, and being married were associated with decreased risk of depression (all at least $p < 0.05$). See Table 1 for the distribution of sample characteristics. Based on unadjusted bivariate analysis, individually assessed (i.e. participant self-reported) neighbourhood problems, low neighbourhood safety, low neighbourhood service quality, and low social cohesion (bonding social capital) and linking social capital were all associated with depression (all at least $p < 0.05$), while neighbourhood aggregated safety reduced the odds of depression ($p < 0.05$)—see Fig. 2. Correlations between individually assessed and collectively assessed neighbourhood characteristics are available in the supplementary file.

All the models to follow have adjusted for the individual-level confounders of age, gender, marital status, and household income. We found that individually assessed neighbourhood problems, neighbourhood safety, neighbourhood service quality, and linking social capital were significantly associated with depression after adjusting for individual-level confounders, but collectively assessed versions of the same variables were consistently not associated with depression (models 1–14, see Fig. 2).

Based on individual reports, one standard deviation (SD) increase on the scale of neighbourhood problems increased the relative odds of depression 1.33 times, 95% CI 1.17–1.50 (model 1), while collectively assessed neighbourhood problems was not linked to depression (model 2). Similarly, one SD increase in neighbourhood safety reduced the odds of depression (OR: 0.76, 95% CI 0.66–0.86) in model 3, but collectively assessed social capital was not associated with depression (model 4). One SD increase in individually assessed neighbourhood service quality significantly reduced odds of depression (OR 0.68, 95% CI 0.60–0.80) in model 5, while collectively assessed neighbourhood service quality was not significantly associated with depression (model 6).

After multivariate adjustments, there were no significant associations between depression and (a) bonding social capital or (b) bridging social capital, using any of the individually or collectively assessed measures (models 7–12). Finally, one SD increase in individually assessed linking social capital was associated with reduced odds of depression (OR 0.85, 95% CI 0.74–0.97) in model 13, but collectively assessed linking social capital was not associated with depression at $p < 0.05$ (model 14).

Discussion

Based on our adjusted models (models 1–14), depression was associated with (1) individually assessed neighbourhood problems, (2) low (individually assessed) neighbourhood safety, (3) low (individually assessed) neighbourhood service quality, and (4) low (individually assessed) linking social capital (all at least $p < 0.05$). However, when the individually assessed exposures were aggregated over residents in the same neighbourhood, none of them were significantly associated with depression: this included collectively assessed neighbourhood problems, neighbourhood safety, service quality, and linking social capital (all of which were previously significant when measured as individually assessed variables). The recommended method to deal with same-source bias, that is by averaging over measurement

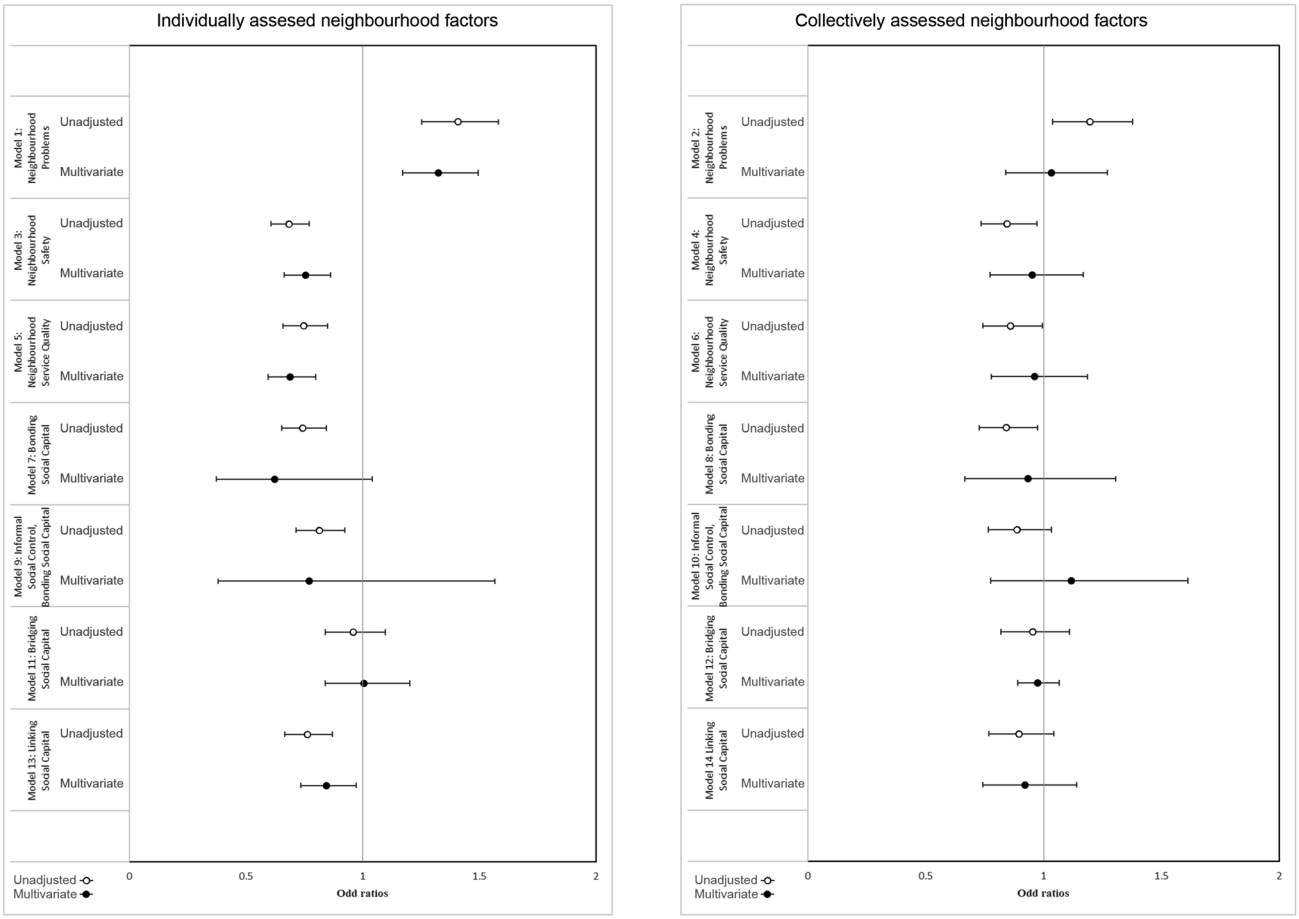

Fig. 2 Forest plot for univariate and multivariate analysis of the association between depression and neighbourhood factors

error across multiple individually assessed responses in the same neighbourhood to produce a more valid neighbourhood measure [19, 20], produced aggregated exposure variables that were no longer associated with depression.

Since the results from individually assessed versus collectively assessed neighbourhood exposures are vastly different, our findings raise questions about the interpretation of previous studies that rely on participants' individually assessed neighbourhood exposures. For example, Latkin and Curry [10] found that self-reported (individually assessed) levels of neighbourhood disorder and appearance is independently associated with depressive symptoms; Kim et al. [23] found that individually assessed neighbourhood disorder and social capital were associated with depression; Phongsavan et al. [24] found that individually assessed neighbourhood-based social capital (i.e. trust on others, sense of safety, and social reciprocity) are associated with lower levels of psychological distress; and Ellaway et al. [22] found that perceptions of neighbourhood-level anti-social and environmental problems, as well as low neighbourhood cohesion, were associated with mental health problems. These studies all point to the possible explanation that poor neighbourhood social environments may increase the risk of depression or mental health problems; however, there is reason to argue that the associations found in these studies may be partly (or wholly) the result of same-source bias (i.e. those with depression may be more likely to report worse neighbourhood conditions). This argument is supported by our study showing that the significant associations between (all) individually assessed neighbourhood exposures and depression were fully attenuated when we switched to using collectively assessed neighbourhood exposures.

Previous studies that use collectively assessed social capital [30] or researcher-assessed social disorder [36] have also failed to find a significant association between neighbourhood social capital (and social disorder) and depression, which further strengthens the argument that responses of individually assessed neighbourhood exposures reflects the individual's mental health state, and may not be a valid measure of actual neighbourhood social conditions. Unlike Stafford et al. [21], who found an association between (individually assessed) social cohesion (i.e. bonding social capital) and depressive symptoms (measured by CES-D), we did not find a significant association between

social cohesion (measured as an individually assessed or collectively assessed exposure) and depression. In addition to potential same-source bias in their study, the reason for the different results may be the depression outcome used, as Fisher et al. [40] noted that CIDI has a higher agreement with clinically diagnosed depression, and less chance for false-positive identifications.

This study has several limitations. First, health-selected migration can occur where healthier individuals are attracted to healthier areas, e.g. individuals without depression may have more time and resources to select an area to live that is more health-promoting. Second, there may be residual confounding that we did not consider in our study beyond what could be captured by age, gender, marital status, and household income. However, it is important to note that the primary purpose of our study is to evaluate the use of individually assessed neighbourhood exposures (as are commonly used in prior studies) to understand how they would hold up after neighbourhood-level aggregation, which increases the validity of the measure by decoupling the neighbourhood measure from an individual's mental health status. Thus, while we can arguably add in more control variables (e.g. self-rated health), to maintain comparability with previous studies which typically controls for gender, age, income, and marital status as individual-level covariates [10, 21, 23]; the "minimally" controlled models allow us to more confidently identify the impact of switching from individual to collective assessment of neighbourhood measures (i.e. the attenuation of effects was more likely due to the switch rather than the use of additional control variables). Third, the use of a cross-sectional design does not allow us to make specific inferences about the direction of causation in our observed associations. However, we are not making an argument that the statistically significant (individually assessed) models support the argument for neighbourhood effects on depression, since the paper is primarily concerned with what happens when we switch from individual to collective assessment, which provides evidence for same-source bias in the individually assessed models (i.e. an argument for reverse causation). Fourth, we use CT as a proxy for neighbourhood, which may be a source of misclassification if CTs do not represent the actual residents' perception of neighbourhood boundaries. However, this problem is partly mitigated by the City of Toronto's high population density, small census tract size, and proximity of residents within the same CT (i.e. mean distance between all residents in the same CT 378 m; SD 204 m).

In conclusion, while the use of collectively assessed neighbourhood exposures can improve measurement validity by decoupling neighbourhood measures from an individual's mental health status (i.e. a suggested solution for same-source bias), we found that the process created neighbourhood social environmental exposures that are no longer independently associated with individual-level depression. We caution future studies from solely relying on individually assessed neighbourhood exposures especially in the study of social environmental influences on mental health outcomes.

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Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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