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Social integration after moving to a new city predicts lower systolic blood pressure

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Impact Statement

This study examines the psychophysiological effects of social integration following a residential move. We demonstrate that making more new social connections predicts decreased systolic blood pressure and improved psychosocial wellbeing among recent movers. These prospective findings complement existing research on the benefits of social connection by directly examining the cardiovascular physiology of movers as they transition into a new community.

Abstract

Residential mobility is linked to higher incidence of cardiovascular disease (CVD) and mortality. A mechanism by which residential relocation may impact health is through the disruption of social networks. To examine whether moving to a new city is associated with increased CVD risk, and whether the extent to which movers rebuild their social network after relocating predicts improved CVD risk and psychosocial wellbeing, recent movers (n = 26) and age- and sex-matched non-movers (n = 20) were followed over 3 months. Blood pressure, C-reactive protein/albumin ratio (CRP/ALB), social network size, and psychosocial wellbeing were measured at intake (within 6 weeks of residential relocation for movers), and 3 months later. Multiple regression indicated higher systolic blood pressure (SBP) for movers (M = 107.42, SD = 11.39), compared with non-movers (M = 102.37, SD = 10.03) at intake, though this trend was not statistically significant. As predicted, increases in movers' social network size over 3 months predicted decreases in SBP, even after controlling for age, sex, and waist-to-hip ratio, b = -2.04 mmHg, 95% CI [-3.35, -0.73]. Associations between increases in movers' social ties and decreases in depressive symptoms and stress were in the predicted direction but did not meet the traditional cut-off for statistical significance. Residential relocation and movers' social network size were not associated with CRP/ALB in this healthy sample. This study provides preliminary evidence for increased SBP among recent movers; furthermore, it suggests that this elevation in CVD risk may decrease as individuals successfully rebuild their social network.

Keywords: blood pressure, SBP, social connection, social network, residential mobility, migration

Social Integration after Moving to a New City Predicts Lower Systolic Blood Pressure

With rapid globalization, the world's population has been more mobile in the past decade than at any time in human history (United Nations, 2020). A greater number of people than ever before live in a country in which they were not born, with an estimated 272 million international migrants in 2019, up from 150 million in the year 2000 (International Organization for Migration, 2020). As residential mobility becomes increasingly common, recognition of the importance of the relationship between moving and physical and mental health has also increased (Oishi, 2010). Moving is associated with long-term health outcomes including higher rates of cardiovascular disease (Exeter, Sabel, Hanham, Lee, & Wells, 2015) and mortality (Oishi & Schimmack, 2010), as well as with poorer self-reported overall health and psychological wellbeing (Brown et al., 2012). However, the proximate effects of residential relocation on health, and the mechanisms through which moving influences health, remain poorly understood (Oishi, 2010; Oishi & Schimmack, 2010).

One mechanism through which moving could impact health is by disrupting social networks. Social relationships have a large impact overall on long-term physical and mental health (House, Landis, & Umberson, 1988; Uchino, 2004), such that lacking social connections is consistently linked to adverse health outcomes including cardiovascular disease and early mortality (Holt-Lunstad, Smith, Baker, Harris, & Stephenson, 2015; Xia & Li, 2018). Notably, the effect of objective social isolation on all-cause mortality persists after adjusting for demographic, health, and psychological factors (Steptoe, Shankar, Demakakos, & Wardle, 2013). Evidence from animal and human studies indicates that social isolation accelerates atherosclerosis (Xia & Li, 2018), increases levels of basal cortisol (Cacioppo, Cacioppo, Capitanio, & Cole, 2015), and is associated with slower post-stressor recovery of systolic blood pressure (Grant, Hamer, & Steptoe, 2009).

Of most relevance to the current work, newly arrived international students with lower levels of social integration in their host community were found to have lower heart rate variability (an indicator of autonomic dysfunction; Thayer, Yamamoto, & Brosschot, 2010), compared to students who were more socially integrated (Gouin, Zhou, & Fitzpatrick, 2015). The higher cardiovascular disease risk associated with fewer social connections, together with evidence of worse autonomic functioning among less socially integrated international students, underscores the need to understand the proximate consequences of a residential move on cardiovascular health and psychosocial wellbeing. However, with the exception of this pioneering study by Gouin and colleagues (2015), the immediate health effects of disrupted social ties caused by moving have not been investigated. It is thus unknown whether and how social integration during a residential transition affects other key markers of cardiovascular health, including blood pressure and inflammation. Most psychological research examining residential mobility has relied on self-reported measures of physical health (e.g., De Maio & Kemp, 2010; Larson, Bell, & Young, 2004; Stokols, Shumaker, & Martinez, 1983) and/or the use of retrospective reports of childhood residential mobility (Brown et al., 2012; Oishi & Schimmack, 2010), and may thus have been prone to memory bias. Although prior work has linked residential mobility to long-term health outcomes such as mortality risk (Juon, Ensminger, & Feehan, 2003; Oishi & Schimmack, 2010) and hospital admission for cardiovascular disease (Exeter et al., 2015), little is known about the actual lived experience of movers or of the impact to their health as they transition into a new community.

Given that the magnitude of the effect of objective social isolation on morbidity and mortality is comparable to, or larger than, the effects of smoking, obesity, and physical inactivity (Holt-Lunstad, 2017; Shankar, McMunn, Banks, & Steptoe, 2011), it is surprising that the influence of changes to social network size on health during residential transition remains understudied. Indeed, evidence suggests that the severity of the physiological risks associated with having fewer social connections may differ depending on life stage (Yang et al., 2016). Thus, as the weeks following a residential relocation are both understudied and a formative period for building social connections (which could have relevance for longer-term social integration), the current study was designed to address the influence of structural changes to movers' social networks during this transitional period on cardiovascular health.

In this study, we investigate the psychophysiological effects experienced by movers in the weeks immediately following their residential relocation in a longitudinal study that measures biological markers in addition to psychosocial outcomes. Specifically, we examine blood pressure and inflammation in recent movers to assess whether relocating to another city is associated with increased cardiovascular disease risk. Higher blood pressure and higher inflammation, as measured by the C-reactive protein to albumin ratio, are both independently linked to increased cardiovascular disease risk (Askin, Tanriverdi, Tibilli, & Turkmen, 2019; Fuchs & Whelton, 2020; Wada et al., 2017; Wu et al., 2015). We also examine whether this hypothesized increased risk is diminished after people live in a new city for three months and start to rebuild their local social network. Specifically, (H1) we hypothesize that individuals who have recently relocated to Vancouver ("movers") will have higher blood pressure and/or elevated C-reactive protein to albumin ratio at intake compared to individuals who have lived in Vancouver for at least five years ("non-movers"). Furthermore, (H2a) we predict that the extent to which movers rebuild their local social network after moving will be associated with improvements in markers of cardiovascular disease risk (i.e., lower blood pressure and/or lower C-reactive protein to albumin ratio) three months later. In addition, (H2b) it is expected that movers who more successfully rebuild their social network will report better psychosocial wellbeing (i.e., lower ratings of depressive symptoms, stress, and loneliness, and higher ratings of social support).

Method

Participants

Two sex- and age-matched (within 5 years of age) samples of healthy English-speaking adults were recruited from the community. The first sample consisted of individuals who had moved to the city of Vancouver, Canada in the previous six weeks ("movers"; *n* = 26, 13 women, *M* = 30.62 years, *SD* = 7.35), whereas the second sample consisted of individuals who had lived in Vancouver continuously for at least the past five years ("non-movers"; *n* = 20, 13 women, *M* = 31.45 years, *SD* = 7.10). Among the movers, the majority (61.54%) reported emigrating from North America (*n* = 8) and Europe (*n* = 8), followed by Central/South America (*n* = 6), Asia (*n* = 3), and Africa (*n* = 1). Reasons reported for moving were varied and included moving for work or job opportunities (*n* = 9), to study (*n* = 7), for new experiences (*n* = 6), for the environment (e.g., weather) (*n* = 3), and as a refugee claimant (*n* = 1).

As we were primarily interested in the formation of new social networks, we recruited only those movers who planned to remain in the city for a minimum of two years and who did not have a well-established social network upon arrival (i.e., individuals who moved from outside the Greater Vancouver Regional District and who did not have family members living in the city). We controlled for other factors known to influence cardiovascular disease risk

(Alhurani, Chahal, Ahmed, Mohamed, & Miller, 2016; Dhingra & Vasan, 2012; World Health Organization [WHO], 2017), by restricting participation to individuals aged 19–55 years who did not suffer from chronic health conditions (including previous coronary artery disease or diabetes), and who were not on hormone therapy (including taking hormonal contraceptives).

We recruited participants by placing advertisements in online and print media (e.g., Facebook; local newspaper), and by posting flyers in the community, including in supermarkets, community centres, and coffee shops. Interested individuals were screened for eligibility via an online survey. All participants provided written informed consent prior to beginning the study, and received $60 CAD upon completion of the study. Forty-six participants (26 movers, 20 non-movers) attended the lab intake session, and 33 participants (19 movers, 14 non-movers) returned for the 3-month follow-up assessment.

Procedure

The procedure consisted of a lab visit and a blood draw at intake (T1), followed by a second lab visit and blood draw three months later (T2). For movers, the first lab visit was scheduled within six weeks of their relocation to Vancouver. At the lab visit, all participants completed questionnaires assessing demographics, social networks, health behaviours, and psychosocial wellbeing, before having their blood pressure and waist-to-hip ratio measured. Participants were then provided a referral form to present at a LifeLabs® healthcare clinic within the next 14 days to have their blood assessed for C-reactive protein and albumin. The same protocol (i.e., lab visit and blood draw) was repeated three months later, after which participants were fully debriefed. The study procedures were approved by the Clinical Research Ethics Board at the University of British Columbia.

Measures

Local social network size. A modified version of the Social Networks in Adult Life Questionnaire (Antonucci & Akiyama, 1987; Pressman et al., 2005) was administered at both intake (T1) and at the 3-month follow-up (T2) to assess local social network size. Participants were presented with a set of three concentric circles and were instructed to think of the circles as "including people who are important in your life right now". Within the innermost circle, participants were asked to write the initials of people "who you feel so close to that it is hard to imagine life without them". Participants were then asked to write the initials of people "who you may not feel quite that close to but who are still very important to you" in the next circle, and finally, to write the initials of people "whom you haven't already mentioned but who are close enough and important enough in your life that they should be placed in your personal network" in the outermost circle. Participants then placed an asterisk next to initials in all three circles that represented individuals living in Vancouver. Local social network size was calculated by summing the number of asterisked initials within all three circles for each participant.

Blood pressure. High blood pressure is one of the largest risk factors for cardiovascular disease (WHO, 2017; Wu et al., 2015), with blood pressure in earlier life predictive of blood pressure and cardiovascular outcomes in older adulthood (McCarron, Smith, Okasha, & McEwen, 2000; Nelson, Ragland, & Syme, 1992). Among blood pressure indices, elevated systolic blood pressure (SBP) has the strongest association with cardiovascular morbidity and mortality, independent of diastolic blood pressure (DBP) levels (Flint et al., 2019; He & Whelton, 1999; Kannel, 1999; Kengne et al., 2009; Stamler, Neaton, & Wentworth, 1989). Blood pressure (SBP and DBP) was measured with an automated monitor (BpTru BPM-100; VSM MedTech, Coquitlam, BC) placed around the nondominant arm after the participant had been seated for 30 min in the lab. As per standardized procedures (Shapiro et al., 1996; Vischer & Burkard, 2016), four blood pressure measurements were taken: the first measurement was discarded, and the average of the subsequent three measurements was recorded. Prior to analyses, one individual was excluded from statistical analyses of both blood pressure and inflammation for having extreme SBP and DBP values (> 4 *SD*s above the mean) that were indicative of hypertension (> 140/90 mmHg; International Society of Hypertension, 2020).

C-reactive protein to albumin ratio. The C-reactive protein (CRP) to albumin (ALB) ratio (CRP/ALB) is an index of acute-phase proteins in the blood used to assess inflammation, and is a prognostic marker of cardiovascular disease risk, morbidity, and mortality (Duman et al., 2019; Park et al., 2019; Ranzani, Zampieri, Forte, Azevedo, & Park, 2013). The ratio of CRP to albumin, as a percentage value, is calculated by dividing CRP (in mg/dL) by albumin (in g/dL), and multiplying the result by 100, with higher values associated with poorer health outcomes (Martin et al., 2019; Oh et al., 2018; Park et al., 2019; Zhang et al., 2019). All participants were asked to refrain from exercising for 3 hr prior to the blood draw (Kasapis & Thompson, 2005), and to not visit the clinic if they were feeling sick or had an infection or a fever (Melbye, Hvidsten, Holm, Nordbø, & Brox, 2004). Female participants were asked to provide a blood sample on a day when they were not menstruating, to reduce variability in CRP linked to fluctuations across the menstrual cycle (Blum et al., 2005; Wander, Brindle, & O’Connor, 2008). The blood draws were analyzed by LifeLabs® (https://www.lifelabs.com) to assess serum CRP and albumin. Thirty-seven participants (22 movers, 15 non-movers) provided blood samples at intake, and 28 participants (16 movers, 12 non-movers) provided blood samples at the 3-month follow-up. LifeLabs® analysis error resulted in CRP data loss for one participant. Prior to analyses, one additional participant was excluded from statistical analyses of CRP due to markedly elevated CRP levels (> 10.0 mg/dL) suggesting the presence of active infection (Landry, Docherty, Ouellette, & Cartier, 2017; Nehring, Goyal, Bansal, & Patel, 2020).

Psychological measures. Psychosocial wellbeing (including depressive symptoms, stress, loneliness, and perceived social support) was measured at both intake and the 3-month follow-up. Depressive symptoms were measured with the 10-item short form of the Center for Epidemiologic Studies Depression scale (CESD-10; Andresen, Malmgren, Carter, & Patrick, 1994), and perceived stress was measured using the 10-item Perceived Stress Scale (PSS; Cohen & Williamson, 1988). Loneliness was assessed with the 20-item UCLA Loneliness scale (Version 3; Russell, 1996), and perceived social support was measured using the 40-item Interpersonal Support Evaluation List (ISEL; Cohen & Hoberman, 1983). Internal consistency for all scales was excellent (Cronbach's αs ≥ .82).

Preregistration

In this article, we report only variables included in our preregistered methods, and only our preregistered *a priori* hypotheses and analyses (OSF preregistration). In the few cases where our analyses diverged from our preregistration, justifications are provided below.

As preregistered, we ended recruitment by December 31, 2019. Since no prior research was similar enough to provide a useful anchor of expected effect size, we initially conducted a conservative power analysis based on the smallest anticipated effect size for our between-subjects analyses. However, due to limited resources and strict inclusion criteria (i.e., healthy movers had to be recruited and attend intake within six weeks of their arrival in the city), our final sample was smaller than originally planned. Despite this, the results of our within-subjects analyses suggest that the effects of moving and social integration on health and well-being are larger than originally anticipated.

Covariates. Following our preregistration, we controlled for the effect of menstrual cycle stage on CRP/ALB by asking women to provide blood samples on days when they were not menstruating. Also following our preregistration, we included age and waist-to-hip ratio as covariates in our models predicting SBP, DBP, and CRP/ALB. Although biological sex was not noted as a covariate in the original preregistration, we decided to control for sex in our models predicting SBP, DBP, and CRP/ALB based on evidence for sex and/or gender-associated differences in blood pressure regulation (e.g., Maranon & Reckelhoff, 2013; Reckelhoff, 2001) and CRP (e.g., Khera et al., 2009; Lakoski et al., 2006). We note that the direction and significance of all our reported findings remain unchanged regardless of whether sex is included or excluded as a covariate in our statistical analyses.

Our preregistered analysis plan also included ethnicity as a covariate; however, given our smaller than anticipated sample size, it was not feasible to include multiple categories of ethnicity in our final analyses. However, including ethnicity as a dichotomous variable (Caucasian vs. Non-Caucasian) does not alter the direction or statistical significance of any reported analyses. Finally, we discovered after finishing data collection at T2 that our measure of waist-to-hip ratio was more reliable and accurate than our measure of body mass index (BMI). Given that waist-to-hip ratio is considered a more reliable marker of cardiovascular risk than BMI across all ethnic groups, ages, and in mixed-sex samples (Yusuf et al., 2005), we included only waist-to-hip ratio and not BMI as a covariate in our final models. The direction and significance of all reported findings remain stable regardless of whether BMI is included or excluded as a covariate.

Bayesian Analyses

In addition to reporting frequentist statistics, we augmented our key hypotheses tests with Bayes factors, as Bayesian analyses are conducive to modelling data from small or unbalanced sample sizes (Kruschke, Aguinis, & Joo, 2012; McNeish, 2016). Specifically, we used Bayes factors to assess the strength of the evidence for differences in cardiovascular health at intake between movers and non-movers (H1), and to assess the strength of the evidence for change in movers' local network size as a predictor of their cardiovascular health (H2a) and psychosocial wellbeing (H2b). Bayes factors were computed using Dienes (2008, 2018) Bayes factor calculator, which requires entering the relevant summary of the data (i.e., the regression slope and its standard error), and a model of the alternative hypothesis. We followed the recommendation to use the raw, rather than standardized, regression slopes (Dienes, 2014, 2019).

For the effects of moving status and changes in social network size on cardiovascular health markers (SBP, DBP, CRP/ALB), we specified a uniform prior distribution with a lower limit of 0 (Dienes, 2014) and a plausible upper limit of 10, based on observed ranges of effects for structural dimensions of social relationships on blood pressure and CRP/ALB (Cuffee, Ogedegbe, Williams, Ogedegbe, & Schoenthaler, 2014; Holt-Lunstad et al., 2015; Hosseini, Veenstra, Khan, & Conklin, 2021; Kamiya, Whelan, Timonen, & Kenny, 2010; Shankar et al., 2011; Smith, Gavey, Riddell, Kontari, & Victor, 2020; Steptoe et al., 2013; Yang, Li, & Ji, 2013). For the effects of changes in social network size on psychosocial outcomes (stress, depressive symptoms, loneliness, and social support) measured on Likert scales, we followed the recommendation to use the ratio of the scales' ranges as the maximum slope, and to specify a half-normal prior distribution with a mode of 0 and a standard deviation of half the maximum (Dienes, 2019). For example, the range of the stress measure (40 – 0), divided by the range of the movers' local network ties (8 – 0) provides the maximum predicted slope of 5 under the alternative hypothesis. Bayes factors (*BF*s) were interpreted according to recommended benchmarks (Dienes, 2014; Jeffreys, 1961), such that *BF*s above 1 provide progressively more evidence for the alternative hypothesis, and *BF*s below 1 provide increasing evidence for the null hypothesis. *BF*s between ~0.33 and ~3 suggest only anecdotal evidence for either hypothesis, that is, the data are insensitive (*BF* close to 1).

Results

Blood Pressure and Inflammation following Residential Relocation

The movers and non-movers did not differ on any of the covariates that were included in the analyses (i.e., age, sex, and waist-to-hip ratio; all *p*s > .320). To test our first hypothesis (H1), whether movers have worse blood pressure and inflammation within the first six weeks of their residential move (compared to age- and sex- matched non-movers), we conducted multiple linear regression models predicting SBP, DBP, and CRP/ALB at intake, in which the explanatory variables were moving status (1 = movers, 0 = non-movers), age, sex (1 = male, 0 = female), and waist-to-hip ratio. We also examined change in SBP, DBP, and CRP/ALB between T1 and T2 by conducting paired-sample *t*-tests for the movers and the non-movers. Descriptive statistics for cardiovascular health markers for movers and non-movers are listed in Table 1.

Blood pressure and inflammation at intake (T1) between groups (H1). Consistent with H1, movers had higher SBP (*M* = 107.42 mmHg, *SD* = 11.39) compared to non-movers (*M* = 102.37 mmHg, *SD* = 10.03) at intake, although this difference did not meet the traditional cut-off for statistical significance, β = .25, *t*(40) = 1.73, *p* = .092; *b* = 5.55 mmHg, 95% CI [-0.95, 12.04]. The $BF_{U[0,\ 10],\ SBP}$ was 3.14, indicating that the data are 3.14 times more likely under the alternative hypothesis (than under the null hypothesis), and is considered substantial evidence that SBP was higher among the movers than the non-movers, at intake. Indeed, the upper quartile, median value, and lower quartile of SBP for the movers at intake were all higher than those for the non-movers (see Figure 1). However, moving status (i.e., being a mover or a non-mover) was not significantly associated with DBP, β = .11, *t*(40) = 0.71, *p* = .481; *b* = 1.89 mmHg, 95% CI [-3.48, 7.26], or with CRP/ALB, β = .06, *t*(29) = 0.35, *p* = .728; *b* = 2.48, 95% CI [-11.95, 16.91], at intake. The $BF_{U[0, 10], DBP}$ of 0.65 and the $BF_{U[0, 10], CRP/ALB}$ of 0.93 suggest that the data are insensitive and do not provide substantial support for either the null or alternative hypotheses.

Change in blood pressure and inflammation between T1 and T2. As expected, average SBP among movers significantly decreased between T1 and T2 (*M* = -4.90 mmHg, *SD* = 8.32), *t*(18) = -2.57, *p* = .019, *d* = 0.59, 95% CI for the difference [-8.91, -0.89]. Also as expected, and in contrast to the movers, average SBP among non-movers was not significantly different between T1 and T2, (*M* = -0.39 mmHg, *SD* = 5.80), *t*(12) = -0.24, *p* = .815 (see Figure 2 for change in SBP for movers and non-movers). However, movers' mean DBP was not significantly different between T1 and T2, , *t*(18) = -1.55, *p* = .140. Similarly, for non-movers, average DBP did not differ between T1 and T2, *t*(12) = -0.79, *p* = .443. Mean CRP/ALB was not significantly different between T1 and T2 for either the movers, *t*(14) = 0.25, *p* = .804, or for the non-movers, *t*(10) = -0.54, *p* = .598.

Social Integration following Residential Relocation

Prior to testing the effects of social integration on blood pressure and inflammation (H2a), as well as on psychosocial wellbeing (H2b), we first conducted a series of *t*-tests to confirm that social integration did indeed differ between movers and non-movers at T1, and that overall, movers were rebuilding their social networks between T1 and T2.

Local social network size at intake (T1) between groups. Not surprisingly, movers had significantly fewer overall local social connections ($M = 2.15$, $SD = 2.38$) compared to non-movers ($M = 10.70$, $SD = 7.12$) at intake, $t(44) = -5.74$, $p < .0001$, $d = 5.01$; 95% CI for the difference [-11.55, -5.54]. Follow-up analyses looking separately at the three levels (inner, middle, and outer circles) revealed that movers had fewer local social connections at all three levels (all *p*s < .001).

Change in local social network size between T1 and T2. As expected, movers' overall local social network size increased in the months following their relocation between T1 ($M = 1.84$, $SD = 2.48$) and T2 ($M = 3.16$, $SD = 2.85$), though this difference did not meet the traditional cutoff for statistical significance, $t(18) = 1.96$, $p = .066$, $d = 0.45$; 95% CI for the difference [-0.09, 2.73]. Increase in movers' local social network size was due to increases in the number of social connections within movers' middle and outer social circles combined from T1 ($M = 1.42$, $SD = 2.29$) to T2 ($M = 2.74$, $SD = 2.62$), $t(18) = 2.01$, $p = .059$, $d = 0.46$; 95% CI for the difference [-0.06, 2.69]. Given that there was no change in the number of social connections in movers' local innermost social circle from T1 ($M = 0.42$, $SD = 0.69$) to T2 ($M = 0.42$, $SD = 0.77$), $t(18) = 0.00$, $p > 0.99$, the decision was made to conduct all analyses predicting changes in movers' blood pressure, inflammation, and psychosocial wellbeing from changes in movers' local social network size using only those social networks that changed in size between T1 and T2 (i.e., movers' local middle and outer social circles combined). Although this decision was not preregistered, we note that the direction and statistical significance of the reported findings remain unchanged if movers' local inner social circle is included in the analyses. Whereas the inner circle typically includes immediate family members, the middle and outer circles are often comprised of individuals, including so-called "weak ties" such as co-workers and acquaintances

(Granovetter, 1973; Huxhold, Fiori, Webster, & Antonucci, 2020), who can represent potentially important links to additional social resources in the wider society (Fuller, Ajrouch, & Antonucci, 2020).

In contrast to the movers, and also as expected, non-movers' social networks did not significantly differ in size between intake and the 3-month follow-up, whether examining overall local social network size or examining the number of social connections in non-movers' inner, middle, and outer social circles individually or in any combination of these circles (all *p*s > .474).

Social Integration as a Predictor of Blood Pressure and Inflammation (H2a)

Linear regression models were conducted to assess whether movers who are more successful in rebuilding their social networks have reduced blood pressure and inflammation. Specifically, we predicted change in SBP, DBP, and CRP/ALB from change in social network size. Consistent with our hypothesis, results indicated that increases in movers' local social network size across a 3-month period predicted decreases in SBP, $\beta = -.70$, $t(14) = -3.34$, $p = .005$, after controlling for age, sex, and waist-to-hip ratio. The $BF_{U[0, 10], \Delta SBP}$ was 41.00, providing very strong evidence for the predicted association between increases in social network size and decreases in SBP among movers. On average, for each additional member of a mover's social network at 3 months, there was a corresponding decrease in SBP of 2.04 mmHg, 95% CI [-3.35, -0.73]. The direction and inferential implications of this association remained unchanged when covariates were not included in the analysis, $\beta = -.60$, $t(17) = -3.09$, $p = .007$ (see Figure 3). Furthermore, increases in movers' social network size marginally predicted decreases in DBP, $\beta = -.40$, $t(17) = -1.80$, $p = .090$, although this trend was not significant when controlling for covariates, $\beta = -.33$, $t(14) = -1.19$, $p = .253$; $b = -0.99$ mmHg, 95% CI [-2.77, 0.79]. The $BF_{U[0, 10], \Delta DBP}$ of 0.37 suggests that the data are insensitive. Change in movers' social network size was not associated with CRP/ALB in analyses without covariates, β = -.17, *t*(13) = -0.61, *p* = .551, or including covariates, β = .08, *t*(10) = 0.37, *p* = .719; *b* = 0.23, 95% CI [-1.17, 1.64]. The $BF_{U[0, 10], \Delta CRP/ALB}$ of 0.06 indicates that the data do not support the predicted association between social network size and CRP/ALB among movers.

As mentioned above, there was no significant change in non-movers' social network size between T1 and T2, and thus, as expected, among the non-movers there was no association between change in social network size and change in SBP, DBP, or CRP/ALB, all *p*s > .573.

Social Integration as a Predictor of Psychosocial Wellbeing (H2b)

We conducted a series of regressions to examine the bivariate correlations between our key variables of interest. First, bivariate regression revealed trends for increases in movers' social network size to predict decreases in depressive symptoms, β = -.44, *t*(17) = -2.03, *p* = .058; *b* = -1.05, 95% CI [-2.13, 0.04], and decreases in perceived stress, β = -.41, *t*(17) = -1.86, *p* = .081; *b* = -1.18, 95% CI [-2.51, 0.16], at the follow-up. The $BF_{HN(0, 1.88), \Delta Depressive}$ was 3.45, indicating substantial evidence for an association between increases in social network size and decreases in depressive symptoms, among movers. The $BF_{HN(0, 2.5), \Delta Stress}$ was 2.45, suggesting only anecdotal evidence for an association between social network size and perceived stress. Change in movers' social network size did not predict changes in either loneliness, β = -.23, *t*(17) = -0.99, *p* = .338; *b* = -1.12, 95% CI [-3.51, 1.28], or perceived social support, β = .19, *t*(17) = 0.81, *p* = .431; *b* = 0.97, 95% CI [-1.56, 3.49] at the follow-up. The $BF_{HN(0, 3.75), \Delta Loneliness}$ of 0.75 and the $BF_{HN(0, 7.5), \Delta Support}$ of 0.34 suggest that the data are insensitive.

Furthermore, in separate bivariate regression analyses, decreases in movers' perceived stress in the months after moving predicted decreases in SBP, β = .52, *t*(17) = 2.50, *p* = .023; *b* = 0.53, 95% CI [0.08, 0.98], and also predicted decreases in DBP, β = .64, *t*(17) = 3.42, *p* = .003; *b*

= 0.67, 95% CI [0.26, 1.09], but were not associated with changes in CRP/ALB, $t(17) = 0.22$, $p = .828$. Decreases in movers' depressive symptoms predicted decreases in DBP, $\beta = .47$, $t(17) = 2.21$, $p = .041$; $b = 0.60$, 95% CI [0.03, 1.18], but were not associated with changes in SBP, $t(17) = 0.95$, $p = .356$, or CRP/ALB, $t(17) = 0.61$, $p = .550$ (see Table 2 for correlations between social integration, blood pressure, inflammation, and psychosocial wellbeing for movers).

As expected, among the non-movers there was no association between change in social network size and change in psychosocial wellbeing (i.e., depressive symptoms, perceived stress, loneliness, and perceived social support), all *p*s > .319.

Discussion

The aim of this research was to examine whether moving to a new city is associated with increased cardiovascular disease risk, and whether the extent to which movers rebuild their social network following their move mitigates cardiovascular disease risk and improves psychosocial wellbeing. This study found preliminary evidence for higher systolic blood pressure among healthy movers within six weeks of their arrival in the city, compared to age- and sex-matched controls. Furthermore, movers who made more social connections in the three months after they relocated showed greater reductions in systolic blood pressure, compared to movers who made fewer social connections. In fact, each additional new social connection was associated with a mean reduction in systolic blood pressure of 2.04 mmHg, an effect comparable to the changes documented in response to programs of endurance exercise or diet modifications (Cornelissen & Smart, 2013; Rebholz et al., 2012; van Mierlo et al., 2006). In addition, trends were observed in the predicted direction between increases in movers' social network size and decreases in depressive symptoms and perceived stress.

Interestingly, the social connections that the movers made which were associated with reduced systolic and diastolic blood pressure were those in their middle and outer social circles, including less intimate and so-called “weak” social ties, such as acquaintances (Granovetter, 1973). In fact, movers reported little to no increase in close social ties (i.e., their “innermost” circle), which is perhaps not surprising given that three months is likely not long enough for most people to develop new social relationships that they describe as being “so close it is hard to imagine life without them.” Our finding that building even weak social connections in a new community prospectively predicts lower blood pressure, and marginally predicts lower depression and stress among movers is in line with previous work indicating that weak social ties contribute to social and emotional wellbeing over and above the benefits of strong social ties (Sandstrom & Dunn, 2014). Our findings are also consistent with a well-documented body of research demonstrating that greater social integration (i.e., having a more diverse social network) confers protective health benefits, including less arterial calcification from cardiovascular disease (Kop et al., 2005), increased resistance to respiratory infection, and reduced age-related cognitive decline (see Cohen & Janicki-Deverts, 2009, for a review). The current study adds to this literature by tracking the development of movers’ social networks in the months immediately following their residential relocation, and prospectively linking increases in movers’ social integration to improved blood pressure.

Although increases in movers’ middle and outer social networks marginally predicted decreases in stress and depressive symptoms, these same increases were not associated with changes in loneliness and perceived social support. The current findings are consistent with research indicating a weak correlation between the objective quantity of social relationships and subjective feelings of loneliness (Coyle & Dugan, 2012). In retrospect, it is possible that our measure of loneliness (i.e., UCLA loneliness scale; Russell,1996) may not have been ideal, as it may have tapped a more stable trait-like aspect of loneliness rather than the dimension of state loneliness (Marangoni & Ickes, 1989). This possibility is supported by the fact that neither the movers nor the non-movers reported changes in loneliness over the 3-month observation period (i.e., between T1 and T2). Interestingly, our findings mirror the results of Gouin et al. (2015), who also measured loneliness with the UCLA scale, and who likewise found that loneliness was not consistently associated either with social network size or with cardiovascular health (i.e., HRV) among newly arrived international students. Furthermore, the social connections that movers made in their first few months in the city may not have been emotionally intense or intimate enough to increase perceptions of social support and reduce feelings of loneliness (Fingerman, Huo, Charles, & Umberson, 2020). Nevertheless, successfully beginning to establish new social connections may have helped decrease feelings of stress and depression, and further opens the possibility for the development of closer social ties that *will* be important for loneliness and social support. Future research following movers over longer periods could help to determine a timeframe in which closer social ties may begin to positively impact loneliness and social support after a residential move. In addition, factors that were not addressed in this study, but which may also influence health during a residential transition, such as socioeconomic status, will likely prove to be a promising avenue for future research (Castañeda et al., 2015). Specifically, future studies could examine the impact of changes in economic standing on health during a residential relocation, for example, by focusing exclusively on movers who are looking to improve their economic circumstances.

In contrast to evidence linking social integration to blood pressure among movers, we did not observe significant associations between social integration and inflammation, or significant differences in inflammation between movers and non-movers. It is possible that low variability in CRP among the current sample of healthy adults may have limited our ability to detect effects. Over a third of the participants who provided blood samples had CRP levels that were too low (i.e., ≤ .30 mg/dL) to be detected precisely by our clinical tests. Furthermore, low baseline CRP among the movers may have obscured associations between social integration and inflammation. In other words, it is possible that forming new social connections in the community did not lead to decreases in CRP because the current group of healthy movers already had low baseline levels of CRP. Similarly, in prior research examining the effect of a 20-week exercise program on CRP in healthy adults, increased physical activity led to decreases in CRP only for individuals with relatively high CRP at baseline (> .30 mg/dL), whereas no change in CRP was observed among individuals with low baseline CRP (≤ .30 mg/dL; Lakka et al. 2005).

Another possibility is that CRP, in comparison with blood pressure, is more stable over time. Past research has shown low variability in CRP among healthy adults when measured multiple times across one year (Ockene et al., 2001). In contrast, average blood pressure may fluctuate among healthy adults, in response to environmental and behavioural factors, when measured over a period of days (Parati, Ochoa, Lombardi, & Bilo, 2013). For example, although increased physical activity is associated with both lower systolic blood pressure (Hegde & Solomon, 2015) and lower CRP (Plaisance & Grandjean, 2006), engagement in a 6-month aerobic exercise program led to decreases in systolic blood pressure, but not CRP, among older women (Ahn & Kim, 2020). Thus, the relative stability of CRP among healthy adults could account for the different patterns of findings that we observed for CRP and systolic blood pressure. Indeed, a third of the movers in our sample showed either no change in CRP or a change in CRP of less than 0.01 mg/dL, across the 3-month study period. It is possible that longer observation periods following a residential relocation may be needed to see changes in inflammatory markers, relative to decreases in blood pressure. Intriguingly, recent research has found that greater social engagement with weak ties, but not close ties, is associated with greater physical activity (Fingerman et al., 2020). Future studies could examine whether increased physical activity mediates the relationship between social integration and cardiovascular health following a residential transition, and whether changes in blood pressure precede changes in inflammation.

Due to the small sample size, caution should be taken when interpreting the differences (or lack thereof) between movers and non-movers in the current study. Although we are unable to calculate an exact participation rate, the extended recruitment time indicates low participation relative to the number of incoming residents to Vancouver. A low participation rate could indicate that our results are at risk of selection bias (i.e., the associations may have been biased toward the null hypothesis because the movers who chose to participate in the study may have experienced lower stress levels than movers who did not participate). Despite this potential for bias towards the null hypothesis, our within-subjects analyses revealed a positive association between social integration into a new community and cardiovascular health, such that movers who established more social connections over time had greater decreases in systolic blood pressure, and a trend for improved psychosocial wellbeing.

This study examined only a small number of participants, and the results are preliminary. However, the current data are consistent with previous research that observed lower HRV among less socially integrated international students (Gouin et al., 2015). Together, these results present an overall picture linking social integration after moving to changes in markers of cardiovascular health. Future research utilizing larger samples could examine the association between social integration and allostatic load, to help determine whether social integration has a disproportionate impact on specific biological systems or influences health more broadly. Larger samples would also enable future researchers to conduct formal mediation analyses that examine whether psychosocial variables such as stress, depression, and loneliness mediate the relationship between moving to a new city and cardiovascular disease risk.

A notable strength of this study was that we were able to directly and prospectively examine the health of movers as they transitioned into a new community, rather than relying on retrospective measures and self-report. These findings indicate that large-scale longitudinal research on the effects of residential relocation and social integration into a new community on physical and mental health is warranted. An implication of the current findings for policymakers is that facilitating the social integration of newcomers into the local community may have direct consequences for population health. For example, after relocating, new residents are often not immediately eligible for public health insurance and may lack healthcare coverage during a period of transition in which they can be particularly vulnerable to poor physical and mental health. Public programs that help movers integrate more successfully into their host communities or that facilitate movers' access to affordable healthcare could act as a preventative measure against the development of more serious illness and longer-term burdens on the healthcare system.

In summary, this study provides preliminary evidence for increased blood pressure, a marker of cardiovascular disease risk, among recent movers and suggests that this increased risk is mitigated by the extent to which movers successfully expand their social network in the months following their relocation. Furthermore, movers who increased their number of social ties in their local community reported a trend of decreased stress and depressive symptoms. In a world in which more people are more mobile than at any time in history, the current findings underscore the importance to health and wellbeing of building social connections, especially for new arrivals to the community.

Compliance with Ethical Standards

Authors' Statement of Conflict of Interest and Adherence to Ethical Standards The authors have no conflicts of interest to disclose.

Ethical Approval All procedures were conducted in accordance with modern ethical standards and have been approved by the appropriate Institutional Review Board.

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Figures

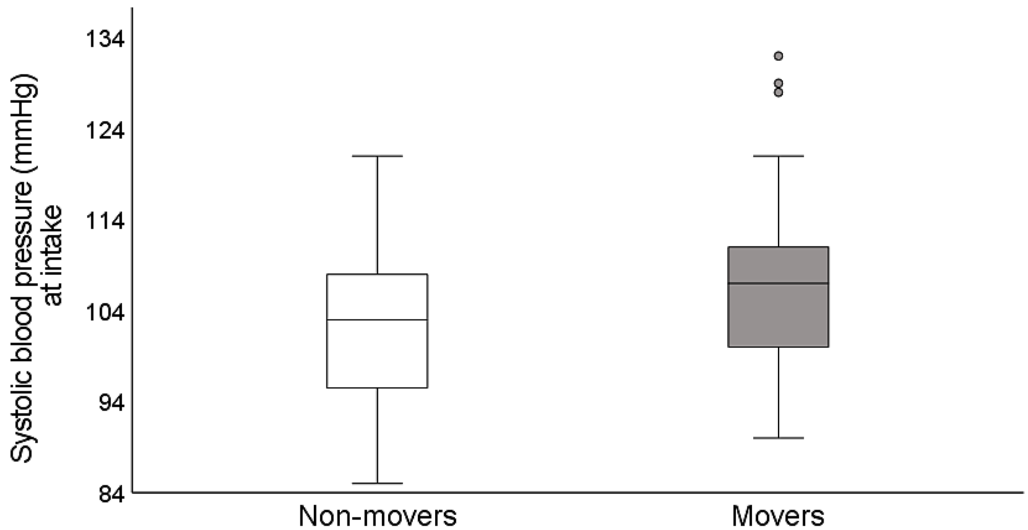

Figure 1. Systolic blood pressure at intake (T1) for movers and non-movers.

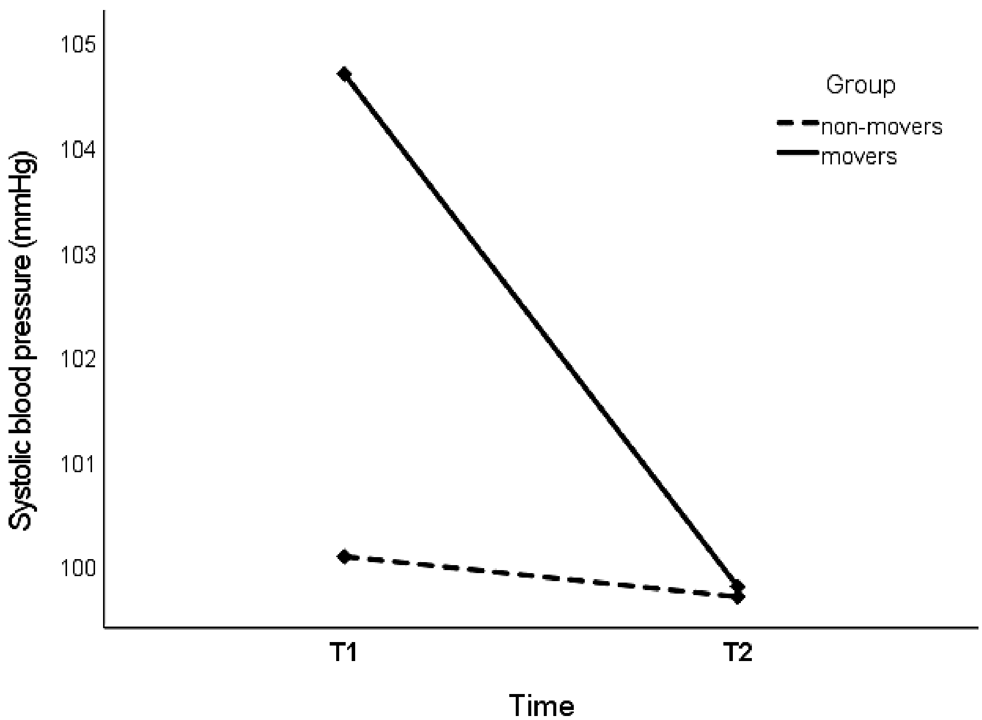

Figure 2. Systolic blood pressure at intake (T1) and at 3-month follow-up (T2) for movers and non-movers.

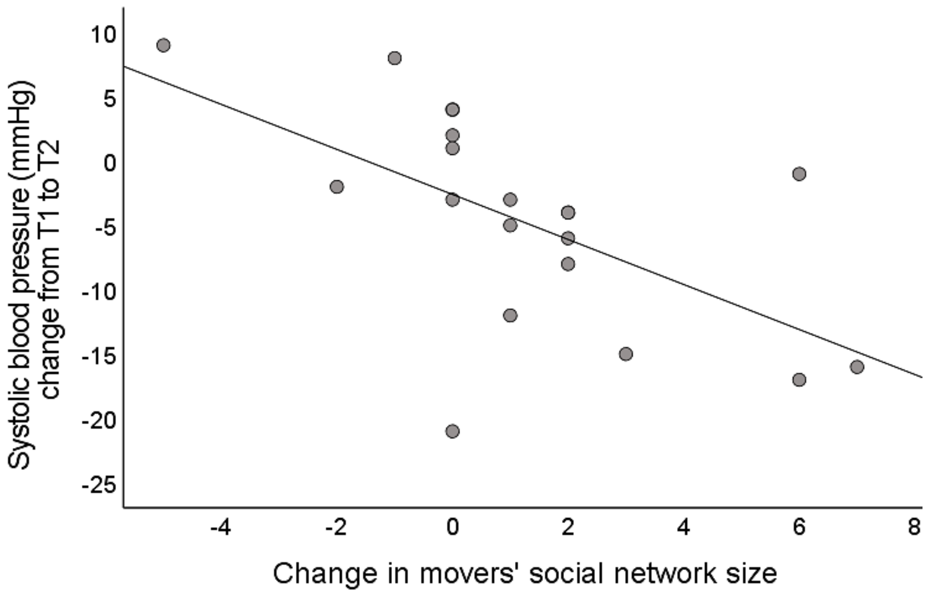

Figure 3. Regression predicting change in systolic blood pressure between intake (T1) and 3-month follow-up (T2) from the change in the number of individuals in movers' social networks.

Tables

Table 1

Cardiovascular Health Markers for Movers and Non-Movers

	Movers			Non-Movers		
	M	*SD*	*n*	*M*	*SD*	*n*
Systolic blood pressure						
T1	107.42	(11.39)	26	102.37	(10.03)	19
T2	99.79	(5.51)	19	99.69	(8.61)	13
Δ T1 to T2*	-4.89	(8.32)	19	-0.38	(5.80)	13
Diastolic blood pressure						
T1	71.81	(8.98)	26	70.32	(8.67)	19
T2	66.63	(5.90)	19	67.54	(7.41)	13
Δ T1 to T2	-3.05	(8.61)	19	-1.54	(7.00)	13
CRP/Albumin ratio						
T1	16.11	(19.80)	21	16.95	(18.51)	13
T2	13.89	(7.92)	15	16.99	(17.44)	11
Δ T1 to T2	0.54	(8.25)	15	-1.72	(10.48)	11

Note. T1 = Time 1 (intake), T2 = Time 2 (3-month follow-up).
*Change is calculated only for participants who provided data at both T1 and T2.
CRP = C-reactive protein. CRP is measured in mg/dL and albumin is measured in g/dL. The CRP to albumin ratio, calculated as a percentage = CRP/Albumin x 100. Blood pressure values are reported in mm Hg.

Table 2

Correlations between Movers' Changes in Social Integration and Changes in Cardiovascular Health and Psychosocial Wellbeing

		1	2	3	4	5	6	7	8	9	10
1	Δ social network size		-.60**	-.40†	-.17	-.22	-.14	-.41†	-.44†	-.23	.19
2	Δ systolic blood pressure			.47*	.01	.04	.03	.52*	.22	.25	-.35
3	Δ diastolic blood pressure				.28	.36	.40	.64**	.47*	.27	-.27
4	Δ CRP/albumin ratio					.99**	-.15	.06	.17	.24	-.12
5	Δ CRP						-.02	.09	.17	.22	-.13
6	Δ albumin							.03	-.18	-.39	.12
7	Δ stress								.72**	.36	-.07
8	Δ depressive symptoms									.56*	-.32
9	Δ loneliness										-.47*
10	Δ perceived social support										

Note. †$p < .10$, *$p < .05$, **$p < .01$. CRP = C-reactive protein.