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Contextual determinants of cardiovascular diseases: Overcoming the residential trap by accounting for non-residential context and duration of exposure

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ABSTRACT

Multilevel neighbourhood analyses rarely account for (1) non-residential exposures and (2) duration of exposure, which have the potential to improve contextual level variance explained, model fit and strength of associations. Using cross-classified logistic regressions, we evaluate the impact of socio-environmental factors at work and home on cardiovascular disease risk for 1626 adults in Toronto-Canada. In the fully-adjusted model, increased CVD risk was associated with poor food environments, lack of parks/recreational facilities, home and work proximity to a major road and noise, and working in a low-SES neighbourhood ($p < 0.05$). Adjusting for exposure duration improved model fit and the strength of associations.

1. Introduction

The geographic extent of everyday lives is not limited to residential neighbourhoods (Naess, 2006). A critical limitation of virtually all multilevel studies of place effects on health is the sole focus on the residential environment, with a few exceptions (Inagami et al., 2007; Muntaner et al., 2006). Chaix (2009) has termed this focus the *residential trap*, because of the exclusive reliance on local residential environments and the systematic neglect of non-residential environments. The purpose of this study is to extend the understanding of place-health associations to non-residential exposures for cardiovascular diseases (CVD), a leading cause of death and disability around the world.

The present study overcomes the residential trap by estimating the impact of socio-environmental risk factors across both home and work environments on CVD (Cummins et al., 2007). We hypothesize that when simultaneously considered, both home and work socio-environmental context will be significantly associated with the risk of CVD.

An additional limitation in neighbourhood health studies has been the failure to investigate how the duration of exposure may modify place-health associations. By excluding time-use in these models, there is an erroneous implicit assumption that people spend similar amounts of time at home. Here, we compare the time-weighted analysis to an unweighted analysis, and we hypothesize that the time-weighted analysis would result in improved model fit and stronger regression coefficients compared to the unweighted analysis as a result of more accurately accounting for estimated time spent in the associated context (Cummins, 2007).

1.1. Literature review

Neighbourhood deprivation is associated with an increased number of adverse cardiovascular outcomes: incidences of myocardial infarction (Lovasi et al., 2008), coronary heart diseases (Diez-Roux et al., 2001; Sundquist et al., 2004; Winkleby et al., 2007), all cause and cardiovascular disease mortality (Smith et al., 1998), and CVD risk factors such as smoking, physical inactivity, obesity, diabetes, and hypertension (Cubbin et al., 2006; Ellaway et al., 1997; Matheson et al., 2010). In these studies, neighbourhood deprivation is a proxy for a range of unmeasured neighbourhood mechanisms, but the lack of information on specific mechanisms diminishes applicability to policy and intervention (Raudenbush and Sampson, 1999).

Research on the distribution of healthy food suggests that its availability is spatially uneven, and negatively associated with neighbourhood deprivation. Evidence suggests that the availability of unhealthy food (*e.g.*, fast food restaurant) is positively correlated with neighbourhood deprivation (Block et al., 2004). Since healthy/unhealthy food has a geographically uneven distribution,

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and accessibility can influence diet, it may be considered an important determinant of CVD risk.

The residential neighbourhood context may also influence CVD risk through its impact on physical activity. A systematic review found that (1) accessibility to facilities for physical activities, (2) awareness and satisfaction of amenities for activities, and (3) aesthetic qualities of the area were consistently associated with increased physical activities even after adjusting for individual characteristics (Humpel et al., 2002). In addition, interest is growing in how planning policies can be used to increase *active transportation i.e.* walking and cycling (Handy et al., 2002), since short daily episodes of moderate physical activity can produce health/cardiovascular benefits (Pate et al., 1995).

Everson-Rose and Lewis's (2005) review found that depression, anxiety, and lack of social support can significantly increase CVD risk, some of which have been found to be influenced by neighbourhood context (Matheson et al., 2006). Neighbourhood psychosocial stressors (*e.g.* rate of violence crime and unemployment) have also been associated with coronary heart disease after controlling for individual-level confounders (Sundquist et al., 2006).

Exposure to motor-vehicle traffic, a source of harmful air pollutants (Dominici et al., 2006; Mittleman, 2007), has also been linked to increased rates of coronary heart disease (Gan et al., 2010), and survival after health failure (Medina-Ramón et al., 2008). While traffic has been used as a proxy for air pollution, Vedal (2009) cautions the effects of traffic may be confounded by traffic noise, which may has its own independent impact on CVD risk that deserves to be studied separately. Our study includes both traffic and noise measures as distinct predictors to estimate their independent contribution to CVD risk.

1.2. Non-residential context and duration of exposure

Few studies consider the non-residential context for health. Among these, Inagami et al. (2007) found that residence in low-SES neighbourhood was associated with poor self-rated health, but exposure to high-SES non-residential neighbourhoods (e.g. neighbourhoods were participants worked, shopped, received medical care, and worshipped) improved self-rated health. Muntaner et al. (2006) also explored the non-residential context for depression. Both studies addressed the work context and both found significant positive association between work neighbourhood socio-economic status and self-rated health or depression. Given the dearth of research on the additional impact of the work neighbourhood context, an exploration of the characteristics that have been theorized to be influential in the residential context may serve as a starting place for generating hypotheses, given that both contexts share features that may influence health behaviours. Neither study, like most other multilevel level studies (Riva et al., 2007), considers duration of exposure to neighbourhood context, which may introduce bias because exposure duration differ between participants. In our study, we account for duration of exposure to try to correct this bias.

Another limitation of Inagami et al. is that the non-residential contexts are treated as *variables* rather than *levels* using a cross-classified approach. Under cross-classified analysis, variance proportions are calculated for each level, which allows us to understand the relative importance of each setting. Finally, Inagami et al. use neighbourhood SES as a proxy for unmeasured contextual factors, which we previously critiqued for its unspecific nature. The use of socio-environmental risk predictors in this study may shed light on the specific pathways that underlie what has generally been referred to as neighbourhood disadvantage.

Based on the research gaps identified above, we ask the following research questions:

1) What is the relative importance of the residential context *vs.* the workplace context for CVD risk?
2) Do residential and/or workplace socio-environmental contexts correlate to the risk of CVDs after adjustments for individual-level risk factors?
3) Does the time-weighted analysis improve model-fit and strengthen the effect size of contextual predictors (compared to unweighted analysis) in models of CVD risk?

2. Methods

The Neighbourhood Effects on Health and Well-being (NEHW) is a cross-sectional study designed to investigate neighbourhood-level determinants of population health. Sampling is three-staged: first, 50 out of the total 140 city-delineated neighbourhood planning areas (NPA) were randomly selected; second, from the 50 NPAs sampled, each containing 2 to 10 census tracts (CT), 1–2 CTs were randomly selected, resulting in 87 randomly selected CTs. CTs are small, relatively stable geographic units with populations between 2500 and 8000 persons, and are often used as proxy for residential neighbourhoods. Third, individuals were randomly selected within each sampled CT based on their residential address. The recruitment target was 30 people per CT, but individuals recruited per CT ranged from 9–31 households (target was reached in 51 out of 87 CTs). Eligibility criteria are as follow: (1) only 1 resident per household, (2) participants are aged 25 to 65, (3) able to communicate in English, and (4) lived in the neighbourhood for at least 6 months. The response rate was 72%.

Data were collected between March 2009 and June 2011. 2411 individuals, representing 87 residential CTs, participated in the study. Participants were excluded from the present study for the following reasons: (1) 706 participants are excluded because they are unemployed/not in the labour force, (2) 24 participants are excluded for not providing a workplace address, (3) 39 participants are excluded for providing workplace addresses that contained incorrect information, and (4) 16 participants are excluded because they worked outside of the Toronto census metropolitan area, where ecological data central to the study are unavailable. This resulted in a sample of $n=1626$. Participants worked across 302 census tracts, with a mean of 5.4 participants working per CT, and 5 census tracts (1.66%) had a single participant. There are 78 additional cases of single participant work CTs, but participants in these 78 CTs worked on a street that is a shared border with a CT that contained other participant work locations. These 78 cases were reassigned into the adjacent work CT to reduce the number of single participant work CTs. Individual-level data were obtained from in-person interviews and participants provided written informed consent at the time of their interview. The Research Ethics Board at St Michael's hospital in Toronto, Canada provided ethics approval for this study.

To ensure that our data are representative of our target population, post-stratification weights were created based on 2006 Canadian Census data for Toronto. The data were weighted by sex, total household income, household size, immigrant status, and age, because our sample is either over/under represented on these characteristics. A weight was created where more weight is placed on the under-represented categories, and less weight on overrepresented cases (Lohr, 1999). Details of the procedure are available by request.

2.1. Outcome, predictors and potential confounders

The CVD outcome is any self-reported physician diagnosis of myocardial infarction (MI), angina, coronary heart disease (CHD), stroke, or congestive heart failure (CHF). This survey did not include