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**Immigrant Rites of Passage: Urban Settlement, Physical Environmental
Quality and Health in Vancouver**

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Immigrant Rites of Passage: Urban Settlement, Physical Environmental Quality and Health in Vancouver

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Abstract: This paper sets out, and provides a preliminary test of, the hypothesis of immigrant rites of passage: that immigrant settlement in Canadian cities is associated with a disproportionate burden of exposure to environmental health hazards. We test this hypothesis with the case of Vancouver, one of Canada's main immigrant gateways, using neighbourhood socioeconomic and air pollution (total suspended particles) data as well as individual socioeconomic and health data. Spatial interpolations are used to assign air pollution to neighbourhoods and individuals and these exposures are combined with socioeconomic markers for analysis in multivariate models including multi-level logistic regressions. The results reveal that immigrant status is in fact 'health protective': that immigrants have lower asthma rates than incumbent Canadians and that air pollution does not exert an effect on either group. The results point to future data needs including analysis stratified by time (for health follow-up) and immigrant group and the need for a wider range of health hazards and health end points.

Key words: immigrant settlement, environmental health and justice, Vancouver

Introduction

Annual cohorts of about 200,000 immigrants arrive to Canada each year and the vast majority settle in cities. Increasingly variegated settlement patterns, reflecting and reinforcing socioeconomic differences among immigrant sub-groups, creates a complex social geography. Equally complex though far less familiar is the manner in which urban spatial externalities, including environmental hazards, are distributed across the urban landscape. We hypothesise that the burden of environmental health hazards in the city falls disproportionately to immigrants and this may be reflected in their health status through time.

Unlike other avenues of immigration research, health has received little attention; environmental health less still. A large and still growing literature on environmental justice in the United States suggests that we ought to be concerned about ambient environmental quality in areas occupied by racial minorities and those of low socioeconomic status. One outcome of this research is substantial policy development beginning with President Clinton's executive order (1994) 12898: "Federal actions to address environmental justice in minority populations and low-income populations." By contrast, Canadian research is only in its infancy; and policy development is non-existent.

Prior research in Hamilton, Canada, found that neighbourhood race/ethnic markers can differentiate ambient environmental quality (Buzzelli and Jerrett 2004). This is suggestive of what we might learn about immigrant settlement, environmental health hazards and the need for policy discussion. Indeed in the larger gateway cities such as Vancouver the immigrant cohort exhibits significant social and spatial variability and the large and heterogeneous landscape intensifies the exchange of externalities. Accordingly, environmental health hazards may be borne disproportionately by immigrants, such as those experiencing stalled social mobility and/or deep deprivation.

In this paper we analyse the interplay of environmental justice, immigrant settlement, and immigrant health in Vancouver using the 1996 National Population Health Survey and monitored ambient air pollution. We aim for mutual development of these three literatures. On the one hand we introduce new approaches to environmental justice via multi-level modelling to both account for spatial scale effects and draw a health connection, both of which are persistent shortcomings of the extant literature. On the other hand Canadian urban immigration viewed through the lens of environmental justice may furnish a new insights in our understanding of immigrant settlement and health.

Immigrant Settlement and the Urban Physical Environment

One of the earliest and most cited set of epidemiological studies of immigrant health concern coronary heart disease in a post-WW2 Japanese cohort. In the context of very low CHD rates in Japan, researchers asked why emigrants (to Hawaii and San Francisco in particular) seemed to take on the disease rates of their destination societies (quarter-century follow-up) while the subset of the cohort who remained in Japan continued to exhibit lower rates. Moreover, the San Francisco group's rates were highest, completing a cross-Pacific health status gradient. One of the original investigators, Michael Marmot, recently reiterated the explanation that "...the more Westernized, the higher the rates...The lessons from Japan, and from studies of Japanese migrants, emphasizes the importance of the social environment in influencing disease rates" (Marmot 2004, 179).

Out of this and subsequent studies crystallised the notion of the healthy immigrant: across a range of measures from self-rated health to clinical/measured outcomes, immigrants tend to be healthier than their host societies. Another consistent finding follows: that with time immigrant health status converges with that of the host society. As in other immigrant-receiving countries (see, for example, the US literature (Jasso *et al.* 2003; Marmot and Syme 1976), and Europe (Doetvall *et al.* 2000; Gadd *et al.* 2003; Razum and Rohrmann 2002, 2001; Silman *et al.* 1985), this stylised account captures the Canadian experience (Kinnon 1998; Chen 1996a/b; McDonald and Kennedy 2004) though recent research has turned up some non-conforming evidence (Newbold 2005; Newbold and Danforth 2003). In general the explanation falls to the selectivity of immigration such that very recent arrivals are healthier, while time insures that 'Western' influences including unhealthy lifestyles, social inequalities and lack of social cohesion/capital and associated psychosocial stress generate disease. Still there is a dearth of immigrant health research relative to other themes of settlement and socioeconomic performance. There is even less known about urban settlement, environmental health hazards, and health effects.

The interplay of immigrant settlement, with its attendant social and economic challenges, and ambient environmental quality may be part of the explanation for declining health status over time. Newbold and Danforth (2003) utilise the same national health survey as in the present study to report disease rates including asthma (same health outcome analysed here): 5.8% for all immigrants, 6.4% for those with at least 10 years of residence; 3.7% for those from the Americas, 8.2% for those from Europe and 4% for those from other regions. In all cases there was a significant difference compared with non-immigrants (8.9%). Asthma among these NPHS respondents conforms to the stylised notion of the healthy immigrant, with longer-term residents and those of European origin (more established) approximating the national average closest.

If immigration research has yet to explore environmental health, a parallel literature based in the United States is devoted to the nature and extent of exposure to hazards especially among racial minorities and the poor: environmental justice. Foundational studies beginning in the 1980s in the United States popularised the notion that environmentalism is not consensual and that environmental quality systemically differentiates communities by race (USGAO 1983; UCC 1987; Bullard 1990). Since then, a tall and wide stack of books, journal articles and government reports have yielded repeated evidence of environmental injustice: from toxic waste facilities to transportation pollution sources; from state- and county-level analyses down to the urban neighbourhood; and from race to more health-oriented work on 'at risk' populations. Though the literature continues to grow, the connection with health outcomes – a rationale for concern over environmental quality – is largely absent. Additionally, health hazard exposure analysis and spatial scale effects remain methodological sticking points (see Buzzelli and Jerrett 2003 for an overview). A focus on immigrant settlement in the Canadian city will address some of these gaps while the theme of environmental justice in turn exposes an unexplored dimension of immigrant settlement: the influence of the ambient physical environment on health status.

Research in Hamilton found that neighbourhood race/ethnic composition can differentiate significant exposure disparities (Buzzelli and Jerrett 2004). Notably, Hamilton's Latin-American population was significantly associated with higher air pollution while the city's South-Asians tended to live in the cleanest neighbourhoods. But immigration to Canada is a metropolitan affair: three-quarters of annual arrivals settle in Montreal, Toronto or Vancouver. Immigrants, especially recent arrivals, usually exhibit high levels of residential segregation. Like health status, time reduces segregation but at least initially spatial distance mirrors social distance. Similarly, ambient health hazards are not spatially homogenous in the urban landscape. Thus it bears asking whether social and environmental inhomogeneity correspond and are associated with adverse health outcomes. It may be that the rising incidence of asthma reported by Newbold and Danforth (2003) reflects life in the neighbourhoods of large Canadian metropolitan areas; perhaps a 'rite of passage' with settlement in Canada.

As an immigration gateway Vancouver presents a unique context with which to explore the rites of passage hypothesis. While immigration to Canada's largest three cities has converged around the themes of increasingly varied settlement patterns, deep deprivation and varied social mobility, each place still remains unique (Hiebert 2000). Montreal and Toronto continue to attract large numbers from the Caribbean, whereas Vancouver's immigrants are predominantly Asian-origin. The

former also receive the majority of refugees to Canada whereas Vancouver's cohort is disproportionately populated by the business immigrant: high status immigrants qualifying for entry on economic points, such as willingness to invest into a new business. Coupled with an expensive housing market unmatched by any other in the country (Ley and Tutchener 1999), there can be deep divisions in settlement patterns: some accommodated in established affluent neighbourhoods (West Vancouver), others finding homes in traditional immigrant reception corridor (e.g. East Vancouver) and others still settling in the suburbs upon arrival (e.g. Cities of Coquitlam and Surrey) (Hiebert 1998; Smith 2004). In a recent cartographic analysis of immigrant concentration and neighbourhood deprivation, Smith shows that the incidence of low income, measures of deprivation and census tract immigrant population can have a high degree of spatial association. Immigrant settlement over the 1991-2001 period was fragmented, suggesting that sub-groups have wide-ranging experiences depending on where they settle in the region.

In the above research all measures of neighbourhood disadvantage are socioeconomic (e.g. unemployment rate). We would overlay such markers of disadvantage with ambient environmental quality. In the present study we use total suspended particles (TSP). TSP is a non-criterion air pollutant (i.e. not regarded as a pollutant to have significant health effects) but has been linked to criterion pollutants (Kim and Jerrett 2000) and used to develop neighbourhood-level health profiles in the urban context (Burra *et al.* 2002). Earlier research in Vancouver has shown that TSP and most other air pollutants have experienced dramatic declines since the mid-1970s. Alongside this trend is a reduction in neighbourhood disparities. However, we still find three orders of magnitude separating the most and least exposed neighbourhoods and clusters of high- and low-exposed neighbourhoods remain (Figures 1, 2a) [Figures on pp. 16-18]. Thus we ask: how does this map onto the social geography of immigrant settlement?

The answer to this question brings the urban physical environment together with the social landscape for mutual development of immigration and environmental justice research. Using multi-level modelling and individual health outcomes we can begin to ask whether environmental rites of passage is a feature of immigrant settlement in the Canadian metropolis.

Methods

To address the rites of passage hypothesis a geographic information system (GIS) was assembled with a range of data sources. Air quality, census SES and individual health and SES data were combined to assign pollution exposures to neighbourhoods and individuals, model exposures in an environmental justice framework and to generate preliminary multilevel health effects models.

Data

Air pollution data were drawn from the regional air quality monitoring network for the period 1976-2001. Using monthly mean values from 32 monitoring stations (Figure 1) as input points, total suspended particles (TSP) data were assigned to Vancouver CMA neighbourhoods using a Bayesian spatio-temporal interpolator (Le *et al.* 2001). Although only 1996 and 2001 TSP estimates were needed for this project more reliable estimates can be produced with long-run data and spatio-temporal prediction. Annual average TSP values were predicted for/assigned to residential-weighted centroids of 295 neighbourhoods/census tracts; these values are also used in the individual and multilevel models for residents of each census tract.

Census data were drawn from Statistics Canada's censuses of 1996 and 2001. The neighbourhood SES markers collected include those now commonly used in environmental justice research: income, family status, employment, educational, immigrant and wealth markers. In order to facilitate pooled analysis of 1996 and 2001 census data, for which we have differing numbers of census tracts (298 and 387 respectively), tracts were merged (by population weighting) and dollar variables were indexed (1996 as base year) for a final set of 295 neighbourhoods. Descriptives are shown in Table 1.

Table 1: Neighbourhood Socioeconomic and Air Pollution Descriptives				
	1996		2001	
CT Variables	Mean	Standard Deviation	Mean	Standard Deviation
TSP ($\mu\text{g}/\text{m}^3$)	25.2	3.97	19.84	2.87
Average dwelling value ¹	\$323,070	\$142,285	\$281,474	\$118,514
% total economic families and unattached individuals below the low-income cutoff	26.39%	11.19%	24.00%	10.46%
Median household income ¹	\$48,107.57	\$13,991.75	\$51,393.80	\$14,726.54
% total population 15 years and older with less than a grade 9 education	7.03%	5.19%	6.45%	5.07%
Unemployment rate	8.53	3.73	7.21	2.69
% of total labour force 15 years and older occupied in manufacturing	9.9%	3.3%	4.2%	2.9%
% lone-parent families	14.0%	5.0%	15.4%	4.6%
% total income from government transfer payments	11.4%	5.7%	10.4%	4.8%
% immigrants	34.1%	13.2%	36.5%	14.1%
1. Adjusted 1996 dollars.				
Sources: Censuses of Canada, Statistics Canada, 1996 and 2001 and GVRD/Environment Canada for the TSP monitoring data				

The third data source was Statistics Canada's National Population Health Survey (NPHS), 1996/7 round. The NPHS is administered as a nationally representative sample (with the exception of populations on Indian Reserves and National Forces Bases) and has several components including the cross-sectional Household Component used in this study. By accessing the data through the Centre for Health Services and Policy Research at the University of British Columbia (<http://www.chspr.ubc.ca/>), BC's NPHS respondent data (H35 file, general personal information; H356 file, a sub-sample with additional health information) could be linked with a range of other data types (linkage via BC provincial health care number) such that an individual data file was built with

the following variables: age, sex, household income (categories), family/household structure (categories), immigrant (binary categories), length of residence in Canada, ethnic origin, racial identity, and level of education. In addition, NPHS data could be linked with 6-digit residential postal codes (roughly equivalent to a city block in urban areas) to permit geolocation of respondents. Thus the NPHS's Vancouver CMA respondents could be georeferenced to specific postal codes, placing them within census tracts for air pollution exposure assignment and subsequent exposure and health outcome models based on a final NPHS variable, asthma (binary categories (H35, 1455 observations, 565 immigrants; H356, 609 observations, 191 immigrants)).

Analysis Steps

Our general aim is to test the notion that immigrants face environmental rites of passage when settling in Canadian gateway cities. Stated as a working hypothesis: immigrant groups and racial minorities face a greater burden of exposure to TSP as compared with Canadian-born residents and whites in Vancouver, and this may result in elevated health effects.

The original research plan was to test this hypothesis by tracking the residential resettlement of NPHS respondents (do immigrants re-settle in more polluted neighbourhoods and is that associated with greater health effects?) over the 1996-2001 period but data limitations do not permit this type of analysis at this time. Instead, we test the working hypothesis with a number of alternative analyses to provide a framework for future data development. First we visualised and explored the pollution and neighbourhood SES data for any spatial coincidence, or hot spots. Second, we produced a neighbourhood-level pooled (1996 and 2001) cross-sectional OLS regression model. The purpose of this analysis is to tease out any relationships between air pollution and SES in 1996 and 2001, both separately and combined. This analysis provides both a standard environmental justice approach but also, with neighbourhood-level SES and TSP associations drawn, an opportunity to explore how sensitive these are to spatial scale effects and how they may (not) transfer to health associations. NPHS data are used in a sensitivity test of spatial scale/aggregation effects in this neighbourhood model.

Addressing our hypothesis more directly, our second approach is a multilevel analysis of health effects. Due to data constraints, whereby our main NPHS file (H35) contains 1455 individual cases, our hierarchical data structure results in fewer than 25 cases per census tract; a bare minimum for stable MLM estimation (Duncan *et al.* 1998). Consequently the neighbourhood SES data are aggregated up to 16 constituent municipalities of the Vancouver CMA (from 19 candidate municipalities of which three had only a handful of cases). With these data, we may analyse which

sorts of neighbourhood SES markers, in particular immigrant and racial status, are associated with asthma. Using HLM 6 software we address this question with the following hierarchical linear model:

$$Prob(Asthma_{ij} = 1 | \beta_j) = \omega_{ij}$$

$$\log[\omega_{ij} / (1 - \omega_{ij})] = \beta_{0j} + \beta_{1...n,j} X_{ij}$$

Where ω_{ij} is the probability of having asthma for individual i nested in city j . β_{0j} is the fixed-intercept of a subject nested in neighbourhood j . $\beta_{1...n,j}$ are coefficients for a X_i vector of individual characteristics within j cities. The level 2 equation is modelled on β_{0j} and is obtained by:

$$\beta_{0j} = \gamma_{00} + \gamma_{0...n,l} X_j + \mu_{0j}$$

β_{0j} is the level 1 model intercept; γ_{00} is its fixed-effect intercept. $\gamma_{0...n,l}$, are fixed-effect coefficients of X_j level 2/municipal SES markers.

Although tenuous as a health model because of the cross-sectional study design and inability to control for antecedent health conditions (part of the original research plan with 1996 and 2001 individual data), substantive results may point to viable hypotheses for future research. As a sensitivity analyses, all final models were re-run using a subset of the linked NPHS data (H356, 609 cases), with smoking as a control variable.

Results

Visualisation and exploration

Data exploration reveals subtle but clear patterns in Vancouver's socioeconomic and air pollution landscape. TSP values are generally low (Table 1) but they do show some marked and consistent variation across neighbourhoods. Reflecting a continuing reduction since the 1970s, average regional TSP dropped between 1996 and 2001 as did the variability across neighbourhoods, but there remained a threefold difference between the most (East Vancouver and up the Fraser Valley) and least exposed neighbourhoods (West Vancouver). Moreover, using a local indicator of spatial association (LISA; see Bailey and Gatrell 1995)¹ reveals several significant clusters of high and low TSP values; clusters that were also consistent in 1996 and 2001 (Figure 2a). Thus hidden

¹ Produced with GeoDa software developed by Luc Anselin. Constructed with a spatial contiguity matrix of the same centroids used in the TSP interpolations, based on a distance threshold of twice the mean distance separating centroids. Rate variables analysed using empirical Bayes smoothing based on total population and 999 permutations. See <https://geoda.uiuc.edu/default.php>.

beneath a low and declining regional average is a spatial disparity in air pollution exposure that may map systemically onto neighbourhood socioeconomic status.

Prior air pollution health and environmental justice research has found that neighbourhood dwelling values and education levels are important markers of exposure and health effects (Buzzelli *et al.* 2003; Krewski *et al.* 2000). Figure 2b repeats the LISA analysis with these neighbourhood SES markers showing a high degree of spatial correspondence between them.² A LISA analysis of the immigration variable shows less correspondence as do most of the other SES data with the exception of low income. Taken as a whole, the SES variables do not show a clear regional pattern corresponding with that of the TSP LISA maps.

Beyond visualising these relationships, a regression analysis may highlight if and how TSP and SES correspond among neighbourhoods. A pooled (1996 and 2001) ordinary least squares model (manual forward selection from most to least significant variables where $p \leq 0.05$, using all the data and with outliers removed) of all SES markers as predictors of TSP (base 10 log) showed several variables to be collinear (such as low education and government transfer payments). The final pooled neighbourhood model produced a moderate fit ($adj. R sq. = 0.467$) to TSP but included only an indicator variable for 1996 ($t = 21.1, p < 0.01$) and neighbourhood percent low income ($t = 6.1, p < 0.01$) as significant. Most of the explanation in this model is in the simple reduction in TSP from 1996 to 2001 rather than in the substantive neighbourhood low income marker. Notably, the immigration variable was non-significant.

The individual SES and health data in this study permit a sensitivity analysis of the above neighbourhood-level model. Tests for sensitivity to alternative spatial scales are rare because data are usually limited. In this case the analysis again confirms the subtlety of relationships but also the importance of spatial scale effects and the potential for multi-level modelling to provide a more comprehensive picture. TSP values were assigned to individuals based on their neighbourhood of residence and these were modeled as outcomes as in the neighbourhood analysis. After removal of outlier cases (leaving 1068 cases from the original 1455) a final weak model ($adj. R sq. = 0.006$)³ did include income ($t = -2.8, p < 0.01$) suggesting two important considerations: first, the nature/direction of the relationship with TSP is consistent but second that spatial scale effects are indeed at play. Once again immigrant status at the individual level was not significant.

² Note that the education and dwelling value maps appear to show an inverse association. We would expect this since the former shows percent low education by neighbourhood which would be negatively correlated with high dwelling values.

³ It should be noted that in the individual data set the income variable is categorical. The loss of variability likely explains the very low fit of this variable in this model and the model result itself.

Immigrant rites of passage: A multilevel of model

The results thus far show that the neighbourhood-to-neighbourhood relationship between TSP and SES are weak to moderate and that immigrant settlement in particular is not associated with ambient air pollution. However the MLM models presented below suggests that immigrant status is important when the analysis accounts for relationships across spatial scales.

Table 2 summarises the MLMs which are logistic regressions with level 1 (individual) data in raw form and level 2 (municipal) variables centred on their grand mean for interpretability. Beginning with Model 1, asthma is the outcome variable (binary outcome of 1 for present and 0 for absent) and TSP is now one of the potential predictors. The intercept is the conditional expected log-odds of asthma for a typical case; that is, for non-immigrant, middle-aged females in a typical municipality. This translates into a survey sample probability of asthma of 6.2%. The probability of asthma changes little with unit changes in the municipal-level variables; percent low education and median income combined produce barely more than a 1% drop in asthma with each unit increase. The former also takes the unexpected sign. We would expect a positive association between low SES and the prevalence of asthma but in this case the sign may be inverted either because the variable is only marginally significant (and subject to collinearity) or that the municipal-level of analysis is simply too coarse to tease out the substantive influence of this variable.

Table 2: Multilevel models of individual asthma in Vancouver, 1996		
	Model 1 (NPHS H35)	Model 2 (NPHS H356)
	(n = 1455)	(n = 609)
	Coef (SE)	Coef (SE)
Intercept	-2.71 (0.42) ^d	-3.72 (0.54) ^d
Individual variables		
Age	-0.01 (0.006) ^b	-
Immigrant (1 = yes, 0 = no)	-0.78 (0.25) ^c	-
Male (1 = male; 0 = female)	0.64 (0.22) ^c	0.83 (0.31) ^c
Smoking status (1 = yes, 0 = no)	-	0.67 (0.32) ^b
Municipal variables		
Median household income	-0.00006 (0.00003) ^b	-0.00008 (0.00004) ^a
% low education	-0.22 (0.08) ^b	-0.31 (0.12) ^b
Note: Coef = coefficient; SE = standard error; a = p < 0.1, b = p < 0.05, c = p < 0.01, d = p < 0.001		

At the individual level, on the other hand, variables carry more of the explanatory power, especially sex and immigrant status. Holding all other variables constant, being male is associated with 1.9 times more odds of having asthma, or an additional 9.6% probability. Immigrant status is associated with a reduction in asthma: 0.46 times less odds or a 3.3% reduction of the probability. In general then most of the explanation for having asthma is found at the individual rather than the municipal level and notably being an immigrant reduces the odds while TSP, albeit a non-criterion air pollutant, does not enter the model as a significant predictor.

As a sensitivity analysis Model 2 makes use of smoking status linked to individuals in the NPHS. This is a smaller sample but the results may suggest where more data development is required. The results are broadly similar, with a survey sample probability of asthma of 2.3% and only weak municipal level predictors. However, inclusion of individual smoking alters the variable mix. Smoking is associated with 1.9 times the odds of having asthma or a 3.6% rise in the probability. Being male again raises the odds, in this model by 2.3 times or a 3.4% greater probability. Age and immigrant status are removed from the model with inclusion of smoking, suggesting misspecification in the larger Model 1 and/or a lack of power with too few cases in this sensitivity model.

Discussion and Conclusion

As a first attempt to test our immigrant rites of passage hypothesis this study raises as many questions as answers. Building on these findings we may pose more specific hypotheses on how rites of passage may play out and identify where data development is needed for more robust analysis.

Bearing in mind data limitations, this study shows that TSP diminished in Vancouver between 1996 and 2001. So too did neighbourhood disparities but there remained so-called hot and cool spots. This sets a general context of potential environmental injustice in immigrant settlement in Vancouver. Is this borne out in the data? The relationship is not as clear cut as in prior Canadian environmental justice research. At the regional level, neighbourhood exposure is most marked by low income residents. An individual-level model testing for spatial scale effects reveals a common pitfall of ecological-associative analysis: that social composition of aggregated spatial units may be subject to ecological fallacy. In this case the nature (direction) of the relationship remains though it is considerably weaker than at the neighbourhood scale. We cannot know if this disconnect in our initial models is an artefact of the NPHS-specific sample or if there is truly more socioeconomic variability within Vancouver CTs than among them.

Accordingly we turn to our main model: a multilevel analysis of asthma and neighbourhood TSP and SES variables. This model is perhaps the best opportunity to identify if any meaning can be attached to the TSP-SES relationship according to immigrant settlement/identity—our main hypothesis. Since TSP is not a criterion health pollutant by environmental epidemiology standards it is not surprising to find it does not significantly help to predict asthma among NPHS respondents. Municipal and especially individual-level SES predictors are more important. What seems to be confirmed is the notion of the healthy immigrant. In the full model a negative association is found with incidence of asthma. However, when smoking is introduced in a smaller control data set for sensitivity analysis individual immigrant status loses its statistical significance.

As in previous immigrant health research (Dunn and Dyck 2000), the results speak to the need for further data development. For example, we cannot be certain that the individual-level immigrant marker loses its significance (in the smoking sensitivity model) for substantive reasons or because of lack of power in the small data set/model. More cases would go some way to addressing this. But we can identify specific data needs for a more comprehensive approach in future research. First, this kind of analysis needs to be stratified in two important ways, by immigrant sub-group and time of arrival. Our results seem to refute the rites of passage hypothesis: immigrants show more muted asthma effects. However we suspect rites of passage apply to some groups and urban regions more so than others. Our Vancouver analysis of all immigrants pooled together may be distorted/muted because of its high proportion of business immigrants. As Ley (1999) argues with respect to social deprivation, aggregation of all immigrants together may mask important details at the sub-group level. Additionally, Vancouver is not typically associated with high levels of pollution, as are eastern Canadian cities such as Hamilton, Toronto, or Montreal, reflecting a legacy of industrialization. In the Vancouver case, therefore, the chance of proving our hypotheses was reduced, while replicating this study elsewhere may prove more fruitful. Second, a larger data set would permit multi-level analysis at the neighbourhood rather than municipal scale. The neighbourhood is a more realistic context of analysis for area-level health effects (e.g. Ross *et al.* 2004). At this scale, for example, we may be able to clarify the result for our low-education variable which may take the unexpected sign in the present paper because of our municipal scale of analysis rather than a true substantive association. Third, rites of passage may be borne out by augmenting the exposures and health effects of concern, from simply incorporating criterion pollutants with known respiratory health effects to analysing a wider range of environmental health end points (e.g. Aramini *et al.* 2000).

Returning to our original intent to test the rites of passage, a simple data set may be enough to tease out effects provided we can track urban re-settlement over time. Analytically this could be conceived of as an interaction variable differentiating residential migration by immigrant status. We can anticipate that residential migration sorts groups (i.e. not individual household respondents) who move to more or less polluted neighbourhoods. Provided enough follow-up time – our original intent, what are the associated health effects? Does health status improve for those whose residential choice improves the ambient environment? Does it worsen for those whose housing careers are more constrained to more polluted neighbourhoods? In a group-stratified analysis, does immigrant status dampen or augment these scenarios, fortifying the notion of healthy immigrants or perhaps dispelling it for some groups and not others? If social polarisation is ever more common in the Canadian city, (MacLachlan and Sawada 1997), especially in large metropolitan areas (Bourne 1997), then some immigrants may face an environmental health triple jeopardy: whereby immigrant status, stalled social mobility/deep deprivation and polluted ambient environments generate a downward health spiral.

If future work seeks to flesh out in a more direct manner the role of residential mobility in environmental health then how can this feed policy development? Though thin, the policy literature on housing mobility and health offers some clues (Acevedo-Garcia *et al.* 2004). For example, since 1986 the Yonkers, N.Y., scattered-site public housing program has sought to desegregate residents by building 200 new units in low-poverty areas. A prospective cohort study controlling for age and pre-existing conditions finds significant improvements among movers in a range of health outcomes such as depression and anxiety (Briggs *et al.* 1999). Even more powerful is the US federal government's Moving to Opportunity Program, a randomised housing mobility policy experiment (in Boston, New York, Baltimore, Chicago and Los Angeles). Begun by the Department of Housing and Urban Development in 1994, the program re-assigns distressed central city residents, usually poor racial minorities, to alternative housing arrangements. Epidemiologists have designed studies around this program by tracking movers and comparing their health status with non-movers as a control/comparison group. Early follow-up results are to some extent mixed and range by study design, site and follow-up period but in general point to improved mental health among movers (children and adults) and some improvements in physical health such as lower obesity rates among adults (Orr *et al.* 2003). From these sorts of studies it is clear that public policy can target health improvements via residential mobility. If immigrant health decline in Canada reflects length of time since arrival then residential sorting among neighbourhoods of varying ambient environmental quality may be an important though as yet unexplored determinant. By building on this study in future research we may learn more about how this plays and what policy options are available to us.

Figure 1: Environmental Rites of Passage: TSP in Vancouver Neighbourhoods, 1996

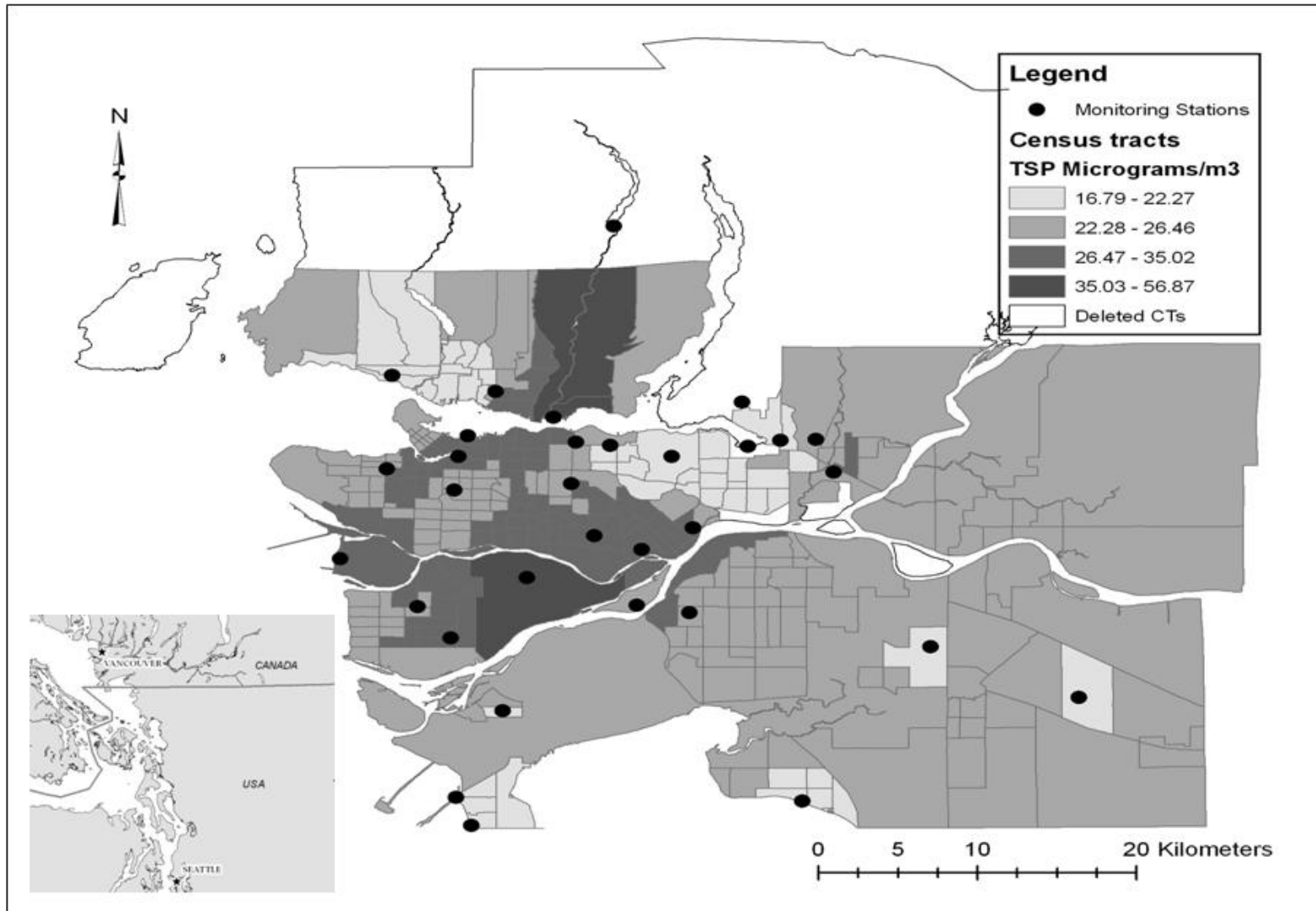


Figure 2: Local indicators of spatial association

Figure 2a: TSP

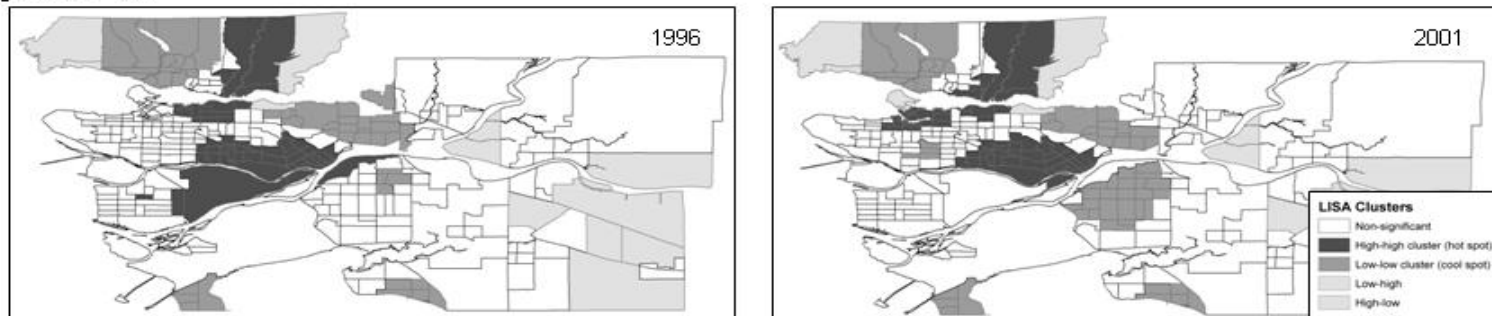
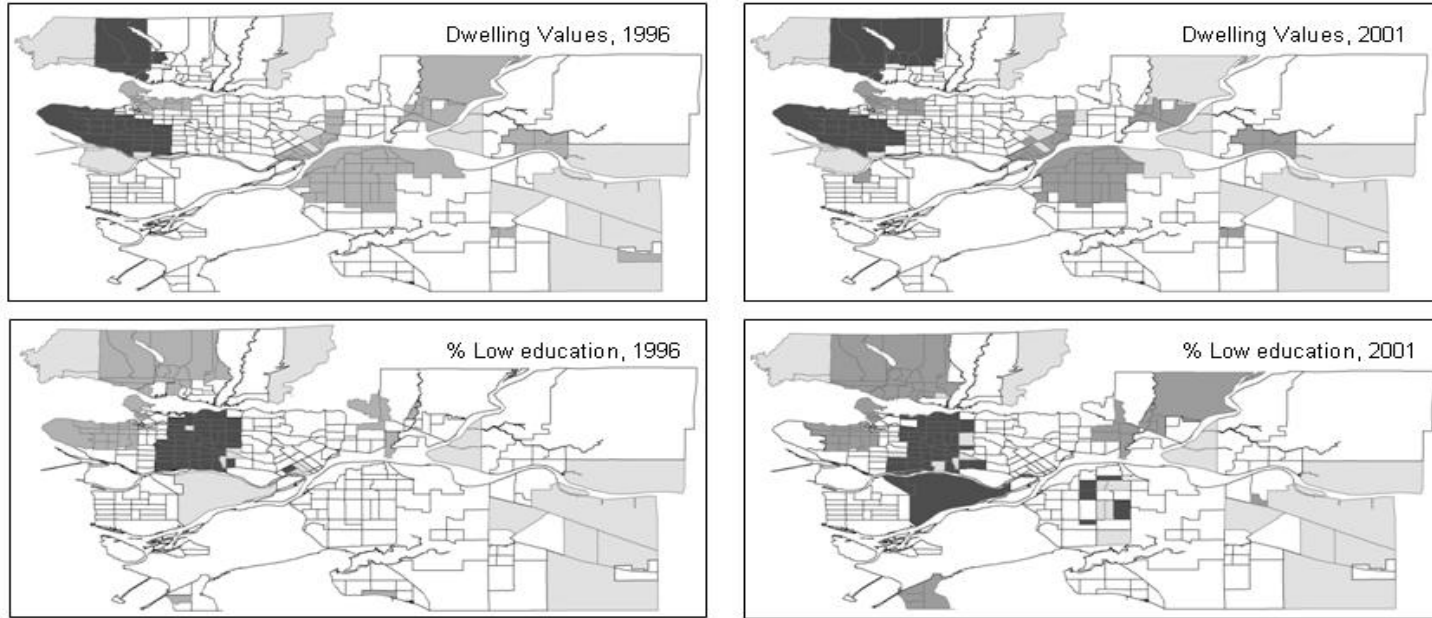


Figure 2: Local indicators of spatial association

Figure 2b: SES



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