Place Effects for Areas Defined by Administrative Boundaries

Michael H. Boyle[1] and J. Douglas Willms[2]

This study estimates the effects of place on the distribution of health problems, health-related quality of life, general well-being, and family functioning for youths and adults aged 12 years and older. Data come from the Ontario Health Survey, a cross-sectional study done in 1990 to provide baseline statistical data on population health within 42 public health units throughout the province. Place effects were generally small and were influenced by both the size of the geographic area used to define place and the health indicator selected for study. Variations in health explainable at the public health region level were less than 1%. Variations in health explainable within smaller geographic boundaries (enumeration areas) ranged from 4.7% for health problems to 0.2% for family functioning. Adjustment for area differences in the age, gender, education, marital status, income, and birthplace of inhabitants reduced these place effects at the enumeration area level to 3.7% for health problems and to less than 0.1% for family functioning. The lack of evidence for place effects within large jurisdictional boundaries raises questions about both the usefulness of carrying out health needs assessment surveys within these areas and the informativeness of these geographic boundaries for studying place effects. *Am J Epidemiol* 1999; 149: 577-85.

epidemiologic methods; health; small-area analysis

A number of disciplines have had a long-standing interest in aspects of place-where we live-that influence health. For example, knowledge about the distribution and determinants of disease studied by epidemiologists is built on the tripartite foundation of person, place, and agent. One of the most important legacies of public health is the seminal role played by social and environmental conditions on the occurrence and spread of infectious disease. Medical geography is concerned explicitly with the quantitative study of disease distributions in which the objects of study, such as health care delivery systems, are geographically defined.

Place effects are contextual or environmental factors that influence individual susceptibility to disease (1). These effects are attributable to the distinctive features of places inhabited by individuals and separable from the individual-level characteristics of inhabitants. The conceptualization of place will have important consequences for the identification of exposures, mechanisms, and effects. For example, conceptualizing place as a physical environment draws attention to physical, chemical, and biologic phenomena with health consequences. Conceptualizing place as a socioeconomic environment draws attention to social and economic phenomena with health consequences. One group of authors has characterized unhealthy environments as those that threaten safety; undermine the creation of social ties; and are conflictive, abusive, or violent (2). The effects of unhealthy environments may be direct (the biologic effects on children of ingesting lead) or indirect (the social and psychologic effects on children of exposure to harsh, negative parenting practices conditioned by living in impoverished neighborhoods).

Studies of place-to-place variations in health pose challenging conceptual and practical problems. For example, places are usually defined by drawing geographic boundaries to create spatial units. The definition of place suitable to the study of health will depend on the health issue (disease and/or exposure) being studied. For example, the spatial units defined to study the effects of air pollution may be different from the spatial units defined to study the effects of resource allocation for health services. In addition to the problems of defining place, there are a myriad of ways in which the effects of place might be revealed. For

example, differences between places may be due to contextual effects that are real or to compositional effects (differences in the characteristics of inhabitants) that are artificial. There may be interactions between people and places that serve to increase or to decrease the risk of susceptibility to disease. Furthermore, the development of spatial units such as neighborhoods is not independent of human agency. People shape their environments and, in turn, are influenced by them; in many instances, the attribution of health effects to individuals, places, or both will be difficult to untangle. Finally, at a practical level, studies of place-to-place variations in health are expensive to implement: They require relatively large samples of places and of individuals within places for adequate estimation and hypothesis testing.

The conceptual and practical problems of studying place effects have prompted researchers to sample places for study on the basis of ready-made geopolitical boundaries. Invariably, the original rationale for creating these boundaries in the past has no bearing on contemporary health issues. However, the jurisdictions formed by these boundaries are usually the focal points for governance, enumeration, and resource allocation and frequently come with an information base useful for characterizing the sociodemography of inhabitants. The availability of such information is a powerful incentive for studying places that serve administrative objectives.

The objective of this research is to evaluate the effects of place on health and functioning in the general population, using definitions of place that coincide with the jurisdictional boundaries of departments of public health in Ontario, Canada. To attain this objective, the analyses address three questions: 1) Is there evidence of significant variation from place to place in levels of health consistent with the presence of place effects? 2) Is the amount of variation in levels of health "explained" by place influenced by the size of geographic area used to define place or the dimension of health examined (health problems, health-related quality of life, subjective well-being, family functioning)? 3) Is variation in levels of health explained by place due to differences in selected sociodemographic characteristics of individuals living in those places (compositional effects)?

MATERIALS AND METHODS

Information for this research comes from the Ontario Health Survey (OHS), a cross-sectional study performed in 1990 to provide baseline statistical data on population health. Details of the survey methods are available elsewhere (3), so only a brief summary appears here.

Target population

The target population consisted of all residents of private dwellings in Ontario during the survey period, January through December 1990. There were some exclusions from the OHS, for example, foreign service personnel, the homeless, people in hospitals and correction facilities, First Nations people living on reserves, and residents of extremely remote areas, but these exclusions constituted less than 5 percent of the total population. The OHS collected information by interview and self-administered questionnaire. The interview was administered to the person in the household most knowledgeable about all residents. Self-administered questionnaires, to be completed by residents aged 12 years and older at the time of the interview, were left with the household and retrieved several days later.

Sampling plan

The sample was obtained using a stratified multistage cluster design. The population of Ontario was stratified by the 42 public health units (PHUs) in the province, and each PHU was further divided into urban and rural strata. The urban stratum of each PHU consisted of the urban core and urban fringe components of any census metropolitan areas (minimum urban core population, 100,000) or census agglomeration areas (minimum urban core population, 10,000) present in the PHU (4). The rural stratum consisted of the remainder of the PHU.

Enumeration areas from the 1986 census constituted the sampling frame for the first stage of sampling for the OHS. (The enumeration area is the smallest geographic unit for which census counts can be retrieved by automatic means. Each one contains a minimum of 375 dwellings in large urban areas and a minimum of 125 dwellings in rural areas). Each enumeration area was classified into either the urban or rural stratum of a PHU. Sufficient enumeration areas (on average, 46) were sampled from each PHU to obtain approximately 760 dwellings in each. The probability of selection for each enumeration area depended on the number of dwellings (census counts) in each one; the larger the number of dwellings, the higher the probability of selection. All of the dwellings determined as being habitable within the boundaries of the enumeration area selected in stage 1 were identified and listed. These listed dwellings constituted the sampling frame for the *second* stage of sampling for the OHS. Simple random sampling was used to select 15 dwellings from each of the urban enumeration areas and 20 dwellings from each of the rural enumeration areas within a PHU. The same number of dwellings *(n = 760)* was

selected from each PHU to ensure that sample sizes and the statistical reliability of estimates were comparable among units at this level.

There were 35,479 dwellings selected for the OHS, and in 87.5 percent of these, a person most knowledgeable was interviewed about the health of all household residents. Self-administered questionnaires left for completion by all household members aged 12 years and older were returned by 49,164 individuals (77.2 percent).

Variables and measures

Place is defined at two levels: 1) the PHU level that, for the most part, follows provincial county designations and defines the administrative areas ($n = 42$) for delivering public health services in the province; and 2) the enumeration area level that defines relatively small clusters of household dwellings for census purposes ($n = 1,925$). As noted earlier, PHUs and enumeration areas were an integral part of the sampling plan for the OHS.

Health problems (HLTHPRB). HLTHPRB experienced by each member of the household in the 12 months preceding the survey were obtained by interviews administered to the person most knowledgeable. The most prevalent problems reported were muscle/skeletal (25 percent), respiratory (23 percent), injuries and poisonings (12 percent), and circulatory (12 percent). The number of reported health problems ranged from 0 to 8.

Health-related quality of life (HRQL). HRQL was measured using the Health Utilities Index Mark III, a multiattribute health status classification system described by eight attributes (vision, hearing, speech, ambulation, dexterity, emotion, cognition, and pain/discomfort), with a range of 5-7 levels per attribute (5-7). The requisite data were obtained by interviews administered to the person most knowledgeable. The health states described by these attributes and levels were converted to health state utilities, anchored at 100.0 (normal health) and 0.0 (dead), based on preference measurements obtained from a representative sample in a separate study.

General well-being (GWB). GWB was a modified version of the Dupuy well-being scale (8). This self-report measure consisted of a request to respondents, "Would you tell us how you felt during the past 12 months?" followed by 14 statements (positively and negatively oriented) that described emotions in seven dimensions: energy, control of emotions, state of morale, interest in life, perceived stress, perceived health status, and satisfaction about relationships. Each statement is accompanied by a standard response option, coded as hardly ever, less than half the time,

more than half the time, and most of the time. After recoding negatively oriented items, item scores were summed to obtain a total scale score that ranged from 0 to 42, with higher scores representing positive well-being.

Family dysfunction (FAMDYS). FAMDYS was based on self-report and measured using the general dysfunction subscale of the McMaster Family Assessment Device (9). The scale consists of an instruction to respondents, "Next are statements about families and family relationships. For each one, mark the circle beside the category which best describes your family..." followed by 12 statements (positively and negatively oriented) that describe family behavior and relationships in six dimensions: problem solving, communication, roles, affective responsiveness, affective involvement, and behavioral control. Each statement is accompanied by a standard response option, coded strongly agree, agree, disagree, and strongly disagree. After negatively oriented items were recoded, item scores were summed to obtain a total score that could range from 12 to 48, with higher scores representing greater dysfunction.

Sociodemographic variables. The sociodemographic variables selected for analysis included sex, age, education, marital status, household income, and place of birth. Information on these characteristics was obtained by interview with the person most knowledgeable.

Sample for analysis

The sample for analysis included all respondents aged 12 years and older who returned self-administered questionnaires ($n = 49,164$). Missing data (excluding the income variable) reduced the sample for analysis to 48,568 persons for HLTHPRB. Rather than eliminating the 7,065 subjects with missing data on income, a dummy variable that indicated lack of response (yes = 1 or no = 0) was included in the analysis. Missing data needed to measure the other health variables further reduced the sample for analysis to 47,219 for HRQL, 42,324 for GWB, and 43,838 for FAMDYS. Sampling weights based on individual probabilities of being selected and participating in the study were used in the analysis to produce unbiased estimates. Table 1 displays the sociodemographic characteristics of residents in dwellings in which a knowledgeable household member agreed to be interviewed (column 2), the same characteristics for subjects returning self-administered questionnaires (column 3), and the distribution of respondents used in the analysis (column 4). The largest difference between columns 1 and 2 pertained to sex: More females returned self-administered questionnaires.

TABLE 1. Percent distributions of respondents on study variables, Ontario Health Survey, 1990

Variables	Sample distribution in households (n = 63,663)	Sample distribution for analysis (n = 49,164)	Weighted sample for analysis (n = 48,568)
Sex			
Male	48.7	46.7	48.7
Female	51.3	53.3	51.3
Age (years)			
12-24	22.0	21.0	22.0
25-44	39.1	39.2	40.1
45-64	25.1	25.3	24.0
>65	13.8	14.5	13.9
Education			
Less than secondary	43.9	43.6	39.5
Secondary complete	34.5	34.4	36.3
Postsecondary	20.3	21.2	24.2
Missing	1.3	0.8	N/A*
Marital status			
Married or common law	63.5	64.9	62.6
Single (never married)	26.4	24.8	27.7
Separated, widowed, or divorced	9.8	10.0	9.7
Missing	0.3	0.3	N/A
Birthplace			
Canada	79.0	80.9	73.3
Outside Canada	20.4	18.9	26.7
Missing	0.6	0.2	N/A
Income			
Below poverty line	12.3	12.4	11.2
Above poverty line to $50,000 per annum	36.2	37.8	33.6
Above $50,000 per annum	34.3	35.1	40.6
Missing	17.2	14.7	14.6

* N/A, not applicable.

Analyses

The data for analysis form a hierarchical structure with four levels. Level 1 is defined by the information collected on individual respondents. This information is nested within families at level 2. Families, in turn, are nested within enumeration areas at level 3, and enumeration areas are nested within PHUs at level 4. The analytic approach taken here is to develop four-level random regression models using MLn (10). Two different models are developed:

$$Y_{hijk} = \beta_0 + (\gamma_h + \theta_{hi} + \mu_{hij} + \epsilon_{hijk}) \quad (1)$$

$$Y_{hijk} = \beta_0 + \beta_1 X_{1hijk} + \beta_2 X_{2hijk}$$
$$+ \ldots\ldots \beta_m X_{mhijk} + (\gamma_h + \theta_{hi} + \mu_{hij} + \epsilon_{hijk}). \quad (2)$$

Model 1 is a simple "null" four-level, random intercepts model in which variation in the response variable Y from the provincial average (the fixed intercept term (β_0) is described with four residual terms: the individual level ϵ_{hijk}, the family level μ_{hij}, the enumeration area level θ_{hi}, and the PHU level γ_h. The variance of these residual terms are σ_ϵ^2, σ^2, σ_θ^2, and σ^2, which estimate between-individual, between-family, between-enumeration area, and between-PHU variation, respectively.

Model 1 is expanded in model 2 to include m fixed provincial effects (the βs) associated with m "predictor" variables (the Xs) for individuals. The predictor variables used in this paper include sex, age, education, marital status, household income, and birthplace. The values for age and income are centered around the provincial mean (by subtracting the mean from each individual score), and quadratic terms (age squared and income squared) are included in each model. The remaining variables are specified as a set of seven dummy variables, one of which identifies subjects with missing data on income. The addition of these fixed effects, measured on individuals at level 1, produces adjusted estimates of the random variation occurring at higher levels. The extent to which these adjustments alter variation between families, enumeration areas, or PHUs indicates the extent to which higher-level variation is attributable to differences in individual-level characteristics (compositional effects). Within the limitations of the model, the residual variation at the place level (enumeration area and PHU), after adjustment for individual-level characteristics, defines the upper limit of place effects on individuals. Sampling probabilities are used to weight information collected from respondents to produce unbiased estimates in all analyses.

RESULTS

Evidence of place effects

Table 2 shows the fixed effect intercepts and random effects variances estimated by the four-level null models used in the analyses. The fixed effect intercepts represent province-wide average estimates. The random effects variances provide an estimate of the "explanatory" power associated with each level. Focusing on HLTHPRB, the random effects variance at level 1 (individual) is 1.663, which is statistically significant (larger than zero). As one proceeds through successive levels of the hierarchy, the random effects variances for health problems are smaller and smaller, although they remain statistically significant. The random effects variances are recalibrated to 100 percent and displayed below the standard errors. The random effects variance at level 1 (between individuals within

TABLE 2. Multilevel null models and random effects variance of health problems, health-related quality of life, general well-being, and family dysfunction, Ontario Health Survey, 1990

	HLTHPRB† (n= 48,568)	HRQL† (n= 47,219)	GWB† (n= 42,324)	FAMDYS† (n= 43,838)
Fixed effect				
intercept	1.58	89.35	45.47	22.12
Random effects*				
Level 1				
(individual)				
σ^2_ε	1.663	200.100	39.680	18.030
(SE)†	(0.015)	(1.854)	(0.374)	(0.169)
%	65.9	68.4	71.9	50.5
Level 2 (family)				
σ^2_μ	0.719	86.460	14.720	17.350
(SE)	(0.017)	(2.073)	(0.401)	(0.286)
%	28.4	28.4	26.6	48.6
Level 3 (EA)†				
σ^2_θ	0.122	7.605	0.670	0.272
(SE)	(0.009)	(0.799)	(0.129)	(0.086)
%	4.8	2.5	1.2	0.8
Level 4 (PHU)†				
σ^2	0.023	1.964	0.151	0.050
(SE)	(0.006)	(0.547)	(0.053)	(0.024)
%	0.9	0.7	0.3	0.1

* All random effects are significant at $p = 0.05$.
† HLTHPRB, health problems; HRQL, health-related quality of life; GWB, general well-being; FAMDYS, family dysfunction; SE, standard error; EA, enumerated area; PHU, public health unit.

families) is 1.663 or 65.9 percent of the total variation in response; between-families variation is 28.4 percent; between-enumeration area variation is 4.8 percent, and between-PHU variation is 0.9 percent. Thus, there is evidence of significant variation from place to place consistent with the presence of contextual effects. Almost all of this place-to-place variation is at the enumeration area level. The variation at the PHU level (0.9 percent) is relatively small.

Influence of health indicator on place effects

The random effects variances for HRQL, GWB, and FAMDYS obtained at levels 3 and 4 (enumeration areas and PHUs) show a different pattern. Compared with HLTHPRB, the place-to-place variation explained at the enumeration area level is smaller: 2.5 percent for HRQL, 1.2 percent for GWB, and 0.8 percent for FAMDYS (table 2). Variation at the PHU level is even smaller: 0.7 percent for HRQL, 0.3 percent for GWB, and 0.1 percent for FAMDYS. Consequently, there is evidence that the amount of variation explained by place is influenced by both the health

indicator selected for analysis and the size of the geographic area used to define place.

Influence of individual characteristics on place effects

Tables 3 and 4 show the fixed effects estimates and random effects variances, respectively, obtained by four-level models incorporating individual-level measures for sex, age, education, marital status, income, and birthplace. In each model, the intercept represents the provincial average for a "prototypical" person. This person would be female, aged 40 years, with a secondary school education, married with a household income of approximately $49,000, and born in Canada. The fixed effects parameter estimates indicate the amount that should be added to or subtracted from the intercept to obtain the estimate for that group. For example, shifting from females to males would lead to a 0.221 decrease in HLTHPRB to an estimate of 1.283 (1.504 – 0.221) (table 3).

Most of the individual-level fixed effects are statistically significant; the exceptions are marked with a dagger. Being male is associated with fewer HLTH-PRB and higher GWB, but more FAMDYS. Being older is associated with more HLTHPRB and lower HRQL. The association between education (relative to completing secondary education), income, and the health indicators follows a predictable pattern (lower levels associated with adverse health consequences). This is also the case for being separated, widowed, or divorced relative to being married. Finally, it appears that being born outside Canada is associated with fewer HLTHPRB, but lower levels of GWB (table 3).

Incorporating individual-level fixed effects decreases the random effects variance observed between families, enumeration areas, and PHUs. The observed estimates are shown in table 4 and should be compared with the random effects variances in table 2 to quantify the impact of adjusting for individual level measures. This comparison is simplified in table 5, which presents the reduction in percent variation explained at the enumeration area and PHU level for each health indicator. On an absolute scale, the largest decrease (from 4.8 to 3.6 percent) is for HLTHPRB, level 3 (enumeration area). On a relative scale, the largest decrease (from 1.2 to 0.6 percent) is for GWB, level 3 (enumeration area).

DISCUSSION

The results of this study indicate that place effects associated with the administrative boundaries of public health in Ontario account for less than 1 percent of the variation in health among inhabitants. Although

TABLE 3. Multilevel model estimates of fixed effects of health problems, health-related quality of life, general well-being, and family dysfunction, Ontario Health Survey, 1990

Effect	Health problems (n = 48,568)		Health-related quality of life (n = 47,219)		General well-being (n = 42,324)		Family dysfunction (n = 43,838)	
	β	(SE)†	β	(SE)	β	(SE)	β	(SE)
Fixed effects								
Intercept	1.504	(0.026)	92.630	(0.257)	45.760	(0.103)	21.210	(0.070)
Male	-0.221	(0.012)	-0.226	(0.139)*	0.774	(0.066)	0.263	(0.045)
Age (years)	0.023	(0.0006)	-0.212	(0.007)	0.0015	(0.003)*	0.044	(0.003)
Age x age	0.000087	(0.000023)	-0.0024	(0.0003)	0.0012	(0.00013)	-0.00052	(0.00009)
Education								
Less than secondary	0.091	(.016)	-2.384	(0.180)	-0.780	(0.085)	0.731	(0.061)
Postsecondary	-0.003	(0.018)*	1.188	(0.211)	0.747	(0.096)	-0.768	(0.071)
Marital status								
Single, never married	-0.018	(0.024)*	0.599	(0.275)	-0.754	(0.129)	2.490	(0.099)
Separated, widowed, or divorced	0.263	(0.025)	-1.553	(0.286)	-2.098	(0.141)	0.544	(0.105)
Born outside Canada	-0.213	(0.019)	0.187	(0.216)*	-0.538	(0.103)	-0.143	(0.076)*
Income level	-0.054	(0.004)	0.732	(0.045)	0.229	(0.021)	-0.170	(0.017)
Income x income	0.011	(0.001)	-0.135	(0.016)	-0.049	(0.008)	0.006	(0.006)*
Missing income	-0.086	(0.024)	-0.821	(0.275)	-0.364	(0.130)	0.355	(0.109)

* $p > 0.05$.
† SE, standard error.

TABLE 4. Multilevel model estimates of random effects of health problems, health-related quality of life, general well-being, and family dysfunction, Ontario Health Survey, 1990

Random effects	HLTHPRB†	HRQL†	GWB†	FAMDYS†
Level 1 (individual)				
σ^2_ε	1.545	194.200	39.280	17.720
(SE)†	(0.013)	(1.723)	(0.369)	(0.166)
%	70.6	72.6	73.8	52.6
Level 2 (family)				
σ^2_ε	0.544	68.160	13.520	15.780
(SE)	(0.014)	(1.809)	(0.385)	(0.268)
%	25.1	25.5	25.4	46.9
Level 3 (EA)†				
σ^2_ε	0.079	4.083	0.307	0.159
(SE)	(0.006)	(0.600)	(0.110)	(0.077)
%	3.6	1.5	0.6	0.5
Level 4 (PHU)†				
σ^2_ε	0.015	0.160	0.130	0.009
(SE)	(0.004)	(0.343)	(0.045)	(0.014)*
%	0.7	0.4	0.2	0.0*

* $p < 0.05$.
† HLTHPRB, health problems; HRQL, health-related quality of life; GWB, general well-being; FAMDYS, family dysfunction; SE, standard error; EA, enumerated area; PHU, public health unit.

TABLE 5. Summary of reduction in percent variation attributable to place effects of controlling for individual-level characteristics, Ontario Health Survey, 1990

Health indicator	% explained variation model 1 -> model 2
Health problems	
Level 3 (EA)*	4.8 → 3.6
Level 4 (PHU)*	0.9 → 0.7
Health-related quality of life	
Level 3 (EA)	2.5 → 1.5
Level 4 (PHU)	0.7 → 0.4
General well-being	
Level 3 (EA)	1.2 → 0.6
Level 4 (PHU)	0.3 → 0.2
Family dysfunction	
Level 3 (EA)	0.8 → 0.5
Level 4 (PHU)	0.2 → 0.0

* EA, enumerated area; PHU, public health unit.

statistically significant, the magnitude of these effects is small. Most of the variation in response is attributable to individual-level differences, with a substantial portion occurring at the family level. Not surprisingly, variation accounted for at the family level increases when assessments focus on the family itself.

Both the size of geographic area used to define place and the dimension of health examined had an impact on the amount of variation in levels of health explained by place. Place defined by enumeration area accounted for 4.8 percent of the variation in HLTHPRB among

inhabitants. In contrast, enumeration area accounted for only 0.8 percent of the variation in FAMDYS. The characteristics of individuals living within places explained some, but not all, of the variation observed at the enumeration area level. In relative terms, controlling for individual-level characteristics had its smallest impact on HLTHPRB, where the percent of explained variation went from 4.7 to 3.7. For GWB and FAMDYS, the variation explained by enumeration area was cut in half by controlling for individual-level characteristics.

Issues in the evaluation of place effects

A number of methodological and conceptual issues have an important bearing on assessing the extent to which places influence the health and functioning of individuals. First, data structures for analyzing place effects are inevitably multilevel (individuals nested within areas) and require special statistical treatment. Analyses that ignore multilevel structures and focus analysis either on individual-level data or on aggregate individual-level data to examine higher-level effects are incorrect and may seriously misrepresent experience. For example, Duncan et al. (11) found that less than 1 percent of the variation in smoking and drinking behaviors among adults in England was attributable to place. They claimed that because their multilevel analysis had controlled for the demographic characteristics of adults living in each place, their estimates were considerably smaller than those reported by an earlier study (12).

Second, there has been little discussion about the link between quantitative estimates of place effects and priorities for research and public health. Opinion seems to vary about what constitutes important variation. One report (13) described place-to-place variation that ranged from 2.4 percent (respiratory function) to 11.1 percent (long-standing illness/disability) as "quite substantial," while another report (11), derived from the same data, concluded that variation ranging from 1.5 percent (drinking) to 5.6 percent (smoking) was "less important than previously implied." On the basis of available studies, including the present one, it appears that most estimates of place-to-place variations in health between -administrative areas fall into the 1.0-5.0 percent range (11, 14, 15) and lend themselves to controversies of interpretation.

Third, in judging the importance of place effects, there is a distinction to be made between explained variance as a summary measure of place effects overall and differences in health outcomes associated with particular places. For example, in this study, the average number of health problems for the province was 1.5, but in about 10 percent of the enumeration areas,

the average number was close to either 1.0 or 2.0 after accounting for individuals' characteristics and for sampling and measurement error. The twofold difference in health problems between enumeration areas at the upper and lower ends of the spectrum are indicative of place effects that are both substantively important and statistically significant.

Multilevel modeling makes it possible to locate places with exceptional outcomes that are not due to the measured characteristics of individuals living within those places. The ability to identify these places may have important public health implications for resource allocation and program planning. In addition, these places are a logical focus of study for discovering mechanisms at the place level that enhance or detract from health. It is important to recognize that explained variance is an estimate of impact, like attributable risk, and it provides administrators and planners with evidence about the overall concentration of health problems in geographic areas. Comparing the size of effects for particular places, like relative risk, focuses on the magnitude of differences for selected places. Both perspectives are important for understanding place effects.

Fourth, estimates of place effects are subject to distortions arising from choices in the sampling of geographic areas, the selection of health outcomes for measurement, and the research design for estimating the impact of place on health. Our study and one other that explicitly modeled two area levels (11) indicate clearly that the smaller the area studied, the larger the place effect. Although rarely documented, this inverse association between size of geographic area and potential to explain variability in health outcomes is hardly surprising. Variation explained by place is a function of between- versus within-heterogeneity of response. As smaller geographic areas are grouped together without reference to health issues, the areas formed by their aggregation can be expected to become more heterogenous, lowering the potential to identify and explain place effects. These examples illustrate the impact of combining areas without reference to health outcomes or hypothesized exposures. It is entirely possible for large geographic areas to explain important components of variability in health. This is contingent on creating geographic boundaries or spaces that maximize between-area differences in exposure (e.g., socioeconomic disadvantage) or response (e.g., neonatal mortality). Empirical methods, such as cluster analysis, provide a statistical means for doing so. In this study, cluster analysis could be used to amalgamate contiguous enumeration areas into "regions" with distinctive socioeconomic profiles. In a subsequent step, one could use multilevel modeling to eval-

uate the extent to which these regions explained variations in health outcomes.

Next, it is clear that the conceptualization and measurement of health outcomes impacts on the quantitative estimates of place effects. There have been too few studies to detect a coherent pattern of effects for different health outcomes (11, 13-15). Results of this study suggest that subjective measures of well-being or family functioning are less sensitive to place effects than are the somewhat more objective measures of physical health. When respondents consider subjective items concerning emotional status, they may base their response on how they feel compared with others in their immediate referent group, rather than how they feel in absolute terms. Thus, their responses are likely to be conditioned by the emotional status of those in their place of residence, which could lead to small variation among places for measures of this type. Further research is needed to clarify aspects of health that may be most susceptible to place effects.

Finally, it is noteworthy that contemporary reports of place effects derived from multilevel modeling have been generated from analyses of cross-sectional data. Cross-sectional designs provide a weak basis for understanding health determinants. Analyses of longitudinal data are needed to discern whether changes in the composition of places effect changes in health outcomes.

Implications

This study and others cited here (11, 14, 15) suggest that place effects associated with large administrative areas are relatively small. This has important implications for both administrators and scientists. Administrators should be selective in their use of area surveys to assess population health. Very often, there will be too little meaningful place-to-place variation between large administrative boundaries to justify intensive data collection for estimating population health. In studies such as the OHS, the decision to provide reliable point estimates for administrative areas such as PHUs is enormously expensive and may limit other study options, such as oversampling certain groups or adding a longitudinal component. Rather than sampling down to administrative units, an option exists to use national or provincial estimates of health status with census-based adjustments to account for individual-level sociodemographic differences between administrative areas. Further, preoccupation with differences in health status between administrative areas, demonstrated to be small in this study, should refocus on differences between administrative areas in resource allocations for health. It is noteworthy that per capita expenditures on health and social services among the 11 municipal regions in Ontario for 1990 ranged from $131 to $433 (16).

Data from this study suggest scientists should be circumspect about using administrative boundaries as sampling frames for testing hypotheses about place effects. The low levels or absence of place effects being detected in recent studies likely reflect the overpowering heterogeneity associated with using areal samples of convenience. To overcome this limitation, places should be defined and sampled purposefully to test specific hypotheses. The point of departure for testing hypotheses about the interplay between persons and places in the production of health are theories about the intermingling of human actions and contextual forces. The salient features of context must be defined so that spatial aggregations can be configured and sampled to adequately represent influences within context that have relevance for human behavior.

In the past decade, the study of place effects has been given a boost by the development of quantitative methods for properly analyzing information collected at multiple levels (1). The availability of such methods, however, cannot make up for weaknesses in sampling, measurement, and design that may lead to spurious inferences about the determinants of health. Attention to methodological issues is always important, but perhaps more so in the study of contextual effects. The reason for this comes from the ongoing debate in epidemiology about the most useful focus for studying disease: biologic or social (17-19). Research on place effects that fail to delineate contextual influences because of weak or faulty methodology will misinform this debate. There is, after all, a lot at stake for the field: the direction of future inquiries into the determinants of health and disease; the development and dissemination of new methods for studying health; and, of course, the allocation of scarce resources to research on health.

REFERENCES

1. Duncan C, Jones K, Moon G. Context, composition and heterogeneity: using multilevel models in health research. Soc Sci Med 1998;46:97-117.

2. Taylor SE, Repetti RL, Seeman T. Health psychology: what is an unhealthy environment and how does it get under the skin? Annu Rev Psychol 1997;48:411-47.

3. Ontario Ministry of Health. Ontario health survey 1990: user's guide. Vol. I. Documentation. Toronto, Ontario, Canada: Ontario Ministry of Health, 1990.

4. Statistics Canada. 1991 census dictionary. Catalogue 92-30 1E. Ottawa, Ontario, Canada: Minister of Industry, Science, and Technology, 1992.

5. Boyle MH, Furlong W, Feeny D, et al. Reliability of the Health Utilities Index Mark III. Used in cycle 6 Canadian General Social Survey questionnaire. Quality Life Res 1995;4:249-57.

6. Feeny D, Furlong W, Boyle M, et al. Multi-attribute health status classification systems: health utilities index. PharmacoEconomics 1995;7:490-502.

7. Torrance GW, Furlong W, Feeny D, et al. Multi-attribute preference functions: health utilities index. PharmacoEconomics 1995;7:503-20.

8. McDowell I, Newell C. Measuring health: a guide to rating scales and questionnaires. New York, NY Oxford University Press, 1987.

9. Byles JA, Byrne C, Boyle MH, et al. The general functioning subscale of the family assessment device: reliability and validity. Fam Process 1988;27:97-104.

10. Woodhouse G, ed. Multilevel modelling applications: a guide for users of MLn. University of London, London, England: Institute of Education, 1996.

11. Duncan C, Jones K, Moon G. Do places matter? A multilevel analysis of regional variations in health-related behaviour in Britain. Soc Sci Med 1993;37:725-33.

12. Blaxter M. Health and lifestyles. London, England: Tavistock/Routledge, 1990.

13. Humphreys K, Carr-Hill R. Area variations in health outcomes: artefact or ecology. Int J Epidemiol 1991;20:251-8.

14. Hart C, Ecob R, Davey Smith G. People, places and coronary heart disease risk factors: a multilevel analysis of the Scottish Heart Health Study archive. Soc Sci Med 1997;45: 893-902.

15. Ecob R. A multilevel modelling approach to examining the effects of area of residence on health and functioning. (Part 1). J R Stat Soc 1996;159:61-75.

16. Ontario Ministry of Municipal Affairs. Municipal financial information, 1990. Toronto, Ontario, Canada: Queen's Printer for Ontario, 1992. (ISSN no. 1180-5994).

17. Krieger N. Epidemiology and the web of causation: has anyone seen the spider? Soc Sci Med 1994;39:887-903.

18. MacIntyre S, MacIvers S, Soomans A. Area, class and health: should we be focusing on places or people? J Soc Policy 1993;22:213-34.

19. Shy CM. The failure of academic epidemiology: witness for the prosecution. Am J Epidemiol 1997;145:479-84.