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**A PROGRAM FOR RESEARCH ON**

## SOCIAL AND ECONOMIC DIMENSIONS OF AN AGING POPULATION

# Health and Individual and Community Characteristics: A Research Protocol

**François Béland, Steve Birch, Greg Stoddart**

**SEDAP Research Paper No. 7**

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Requests for further information may be addressed to:
Secretary, SEDAP Research Program
Kenneth Taylor Hall, Room 426
McMaster University
Hamilton, Ontario, Canada
L8S 4M4
FAX: 905 521 8232
e-mail: qsep@mcmaster.ca

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# ABSTRACT

## HEALTH AND INDIVIDUAL AND COMMUNITY CHARACTERISTICS: A RESEARCH PROTOCOL

**François Béland, Université de Montréal**
**Steve Birch and Greg Stoddart, McMaster University**

Population health policies tend to target communities to enhance the health status of individuals. However, little is known about the effects of community or socio-economic environmental variables on individual health characteristics and behaviour patterns. This paper outlines procedures designed to examine the contribution of context in producing health.

# HEALTH AND INDIVIDUAL AND COMMUNITY CHARACTERISTICS:

# A RESEARCH PROTOCOL

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Population health policies tend to target communities to enhance the health status of individuals. However, little is known about the effects of community or socio-economic environmental variables on individual health characteristics and behaviour patterns. The main objective of this study is to examine the contribution of context in producing health.

Changes in health status (physical and mental) of individuals between two time periods will be studied to determine the relevant sets of individual and environmental factors and estimate their respective contributions. Variables are classified into three domains. First, the dependent variable, health status, is multidimensional: diseases, functional limitations, disabilities, cognitive deficits, psychological well-being, and self-perceived health are considered. Second, individual level effects on health status are patterned as suggested in the individual-level stress model: social support, psychosocial variables and socio-economic characteristics are considered as resources mobilised against stress. Third, ecological level variables describe the socio-economic environment of individuals.

The operational objectives of this research project are to:

1a) Identify contextual variations in the health status indicators.

b) Describe changes in health status in the individual and contextual dimensions.

2a) Test the individual level stress model with longitudinal data.

b) Introduce the contextual dimension in testing the individual-level stress model with longitudinal data. This step will help to identify the robustness of contextual variations in the health status indicators and test for significant contextual variations in the regression coefficients for individual-level health status predictors.

3a) Test for statistical significance of regression coefficients of contextual-level variables.

b) Test for interactions between contextual-level and individual-level variables. Only individual-level variables with regression coefficients that differ among contexts will be considered.

**Definition of contextual effect**

Continuing concerns with systematic and persistent variations in health among populations have been associated recently with increased attention by researchers to the development of broader conceptual frameworks for explaining the production and distribution of health within populations (Hancock, 1986; Gunning-Schepers and Hagen, 1987; Evans and Stoddart, 1990; Hurowitz, 1993). In these frameworks, traditional interest in genetic factors and access to health care as determinants of health is complemented by recognition of the potential roles of individual lifestyle (Lalonde, 1974) and, more recently, the environment and context in which one lives (Epp, 1986; Syme, 1994).

The social, economic, physical and cultural environments in which people live, work and

play, and in which they experience a wide range of emotions over both short and long periods, are the particular focus of one synthesis of research evidence on determinants of health (Evans, Barer and Marmor, 1994). The conceptual framework used to organize and integrate this evidence (Evans and Stoddart, 1990) emphasizes the role of social environment in conditioning the behaviors and "choices" of individuals and in doing so, shifts the focus of health determinants from individuals to groups and their socioeconomic and cultural contexts.

Theoretical concerns about the role of contexts on population health have been accompanied by the development of empirical research on the import of contexts on individual health status and on identifying contexts' features associated with health status variations.

Our interest in better understanding the effect of context on health led us to a careful examination of both the definition of a "contextual effect" and the empirical methods for appropriate investigation of such effects. In this paper, we propose a definition of "contextual variation" and "contextual effect".

Some of the recent research on the role of contextual influences on health and lifestyles has used ordinary least square (OLS) regression (Robert, 1998; Aneshensel and Sucoff, 1996; Blake Turner, 1995; Blaxter, 1990). Other authors used hazard model (Leclere et al., 1998; Hayward et al., 1997; Waitzman and Smith, 1998). The work of Robert (1998) and Turner (1995) were based on the Americans' Changing Lives (ACL)

study in which too few cases were available in each context to introduce measures of variations of individual-level characteristics within contexts. Hayward et al. (1997) and Aneshensel and Sucoff (1996) grouped contexts into small numbers of categories and went on with stratified analysis. Waitzman and Smith (1998) controlled for autocorrelation of individuals living in the same context. Finally, contextual-level variables were introduced to explain contextual-level variations in the level of health status and in the individual-level effects. Jones and Duncan (1995) used multi-level model (Goldstein,1995). Diez-Roux et al. (1997) and O'Campo et al. (1997) were able to show contextual variations on CHD prevalence and low birth weight, using multi-level procedures.

Duncan et al. (1996) and Diez-Roux et al. (1998) suggest that including multiple level of measurements, one at the individual level, others taking into account multi-level contexts, introduces such complexities in the modeling of health status, that theoretical models at the individual and contextual levels are needed. However, as Duncan et al. (1996) stated, although no such models are available up to now, useful research can be accomplished nonetheless. A good starting point is to define a contextual variation and a contextual effect. From these definitions, terms in a multi-level mathematical model can be assigned specific roles in the estimation of multi-level variations and effects and a better understanding of the procedural steps required to go through a multi-level analysis may be obtained.

Birch et al. (1999) defined a community (contextual) variation 'to be a variation in an individual-level dependent variable (the health of individuals) embodied within communities that is explained through individual-level processes (the determinants of individual health) that differ among communities'.

According to this definition, a study of contextual variations will examine whether: 1) the distributions of continuous or discrete health states vary among communities; and 2) individual-level processes generating health states are the same among communities. These two research questions can be described straightforwardly using linear regression notation. The first question is descriptive in intent: does the average of the individual-level health status indicator ($h_{ij}$) vary among the contexts? Individual scores on the health status indicators thus depend on three terms: 1) the general mean $\bar{a}_j$ in the sample; 2) individual error terms $e_{ij}$, measuring variation between 'i =1 to I' individuals on the dependent variable; and 3) contextual error terms $g_j$, measuring variation between 'j =1 to J' contexts on the dependent variable:

(1) $h_{ij} = \bar{a}_j + e_{ij} + g_j$

where $\bar{a}_j$ is the weighted average of $h_{ij}$ over 'J' contexts. The weights are a function of number of individuals in each of the contexts. The dependent variable $h_{ij}$ will vary among contexts if the standard error of $g_j$ is significantly different from zero. Equation (1) does not include any individual-level independent variables describing a process from

which $h_{ij}$ is generated. Let us say that a vector of K independent variables is used to describe such a process. Equation (1) can be modified to include their effects:

(2) $h_{ij} = \bar{a}_j + g_j + \sum_k \overline{\mathrm{B}}_{kj}\Omega_{kij} + e_{ij}$

where $\overline{\mathrm{B}}_{kj}$ is a vector of weighted average regression coefficients over contexts, estimating the $\Omega_k$ effects of the K independent variables. However, in equation (2), the individual-level process represented by the vector of individual-level dependent variables is the same in each of the 'j' contexts. To represent contextual-level variations in the individual-level process, regression coefficients $\overline{\mathrm{B}}_{kj}$ have to vary among communities:

(3) $h_{ij} = (\bar{a}_j + g_j) + \sum_k (\overline{\mathrm{B}}_{kj} + m_{kj})\Omega_{kij} + e_{ij}$

terms $m_{kj}$ measure variations in the K regression coefficients attributable to the J contexts.

Equations (1), (2) and (3) represent the contextual-level model inasmuch as contextual-level variations are taken into account in the estimation of parameters use to define individual-level characteristics or processes. The Birch et al. (1998) definition of the contextual-level effect is totally defined with equation (3): 1) the dependent variable is an individual-level variable with variation at the individual and contextual-levels; 2) individual-level variables describe a process generating the dependent variable; and 3) the hypothesized individual-level process is shown to vary between communities.

The Birch et al. (1999) definition of contextual effects leaves open the explanation of individual-level characteristics and processes by contextual-level characteristics. Let say that it is possible to identify a contextual-level process, defined by 'L' number of contextual-level characteristics $\Gamma_{lj}$, to explain, first, contextual-level variations in the $a_j$ intercepts, and second, contextual-level variations in the $\mathrm{B}_{kj}$ individual-level effects. In equation (3), the $a_j$ intercepts are represented by the expression '$\bar{a}_j + g_j$' and the $\mathrm{B}_{kj}$ individual-level effects are represented by the expression '$\overline{\mathrm{B}}_{kj} + m_{kj}$'. Thus:

(4) $a_j = \bar{a}_j + g_j$ and

(5) $\mathrm{B}_{kj} = \overline{\mathrm{B}}_{kj} + m_{kj}$

both $a_j$ and $\mathrm{B}_{kj}$ can be substituted in equation (3) for their expression, giving:

(6) $h_{ij} = a_j + \sum_k \mathrm{B}_{kj}\Omega_{kij} + e_{ij}$

Contextual-level variables can be used to predict both $a_j$ and $\mathrm{B}_{kj}$:

(7) $a_j = \bar{a}_j + \sum_l \Phi_l' \Gamma_{lj} + g_j$ and

(8) $\mathrm{B}_{kj} = \overline{\mathrm{B}}_{kj} + \sum_l \Phi_l'' \Gamma_{lj} + m_{kj}$

where vectors of $\Phi_l'$ and $\Phi_l''$ represents regression coefficients associated with contextual-level characteristics. Equations (7) and (8) can be compared with equations (4) and (5). In (4) and (5), all the contextual variations are attributable to the two error terms $g_j$ and $m_{kj}$ in contrast to (7) and (8) where part of the contextual variation is attributable to specific contextual characteristics. Thus, contextual characteristics in equations (7) and (8) are linked explicitly with contextual variations.

Expressions for $a_j$ and $\mathrm{B}_{kj}$ in equations (7) and (8) can be brought back in equation (6) to give an equation for a multi-level model with both individual-level and contextual-level processes generating the dependent variable distribution:

(9) $h_{ij} = (\overline{a}_j + \sum_l \Phi_l' \Gamma_{lj} + g_j) + (\overline{\mathrm{B}}_{kj} + \sum_l \Phi_l'' \Gamma_{lj} + m_{kj})\Omega_{kij} + e_{ij}$

The second term of equation (9), $\sum_l \Phi_l' \Gamma_{lj}$, contains the vector of regression coefficients for direct effects of contextual-level variables. This term is entered in the model only after contextual-level variations in the intercept and individual-level regression coefficients have been considered in the equation. Thus, building a contextual-level effects model from a definition suggests that contextual-level direct effects should not be entered on their own, as in O'Campo et al. (1997), unless they are not interpreted in a multi-level context. The third term in equation (9) includes interactions of individual and contextual-levels variables as expression $\sum_l \Phi_l'' \Gamma_{lj}$ is premultiplied by $\Omega_{kij}$, the vector of individual-level independent variables. However, contextual-level variables are entered in a model where: 1) an individual-level process has already been considered; and 2) contextual-level variations are defined with explicit terms. These two characteristics are basic for not rejecting a contextual-level model.

The Birch et al. (1998) definition of contextual-level variation can be extended to include a contextual-level effect:

- a contextual variation is 1) a variation in an individual-level dependent variable embodied within communities that is explained through individual-level processes that differ among communities and 2) a variation in an individual-level dependent variable that is explained through individual-level processes that differ with contextual-level characteristics.

In this research project, contextual-level variations and effects are examined with equations (1), (3) and (9) adapted to longitudinal data.

**Materials and Methods**

a) Sample

Two types of data are needed in this research project. First, individual-level data and, second, data on their contexts. Data on individual health status, personal and social sources of stress, financial, cultural, social and interpersonal resources, psychosocial characteristics and health behaviors are from the 1994 and 1996 National Population Health Survey (NPHS). Contextual-level data are census data linked to individuals through census tracts.

The NPHS sample is a household sample (Statistique Canada, undated). A total of 26,429 households have been selected. One individual was asked, in each household, to participate in the survey. Response rates were 88.7% at the level of household and 96.1% for individuals. Thus, by all standards, the NPHS sample size is large. However, sample size in multilevel analysis has to be assessed considering the overall sample

size and the number of observations in each context. In this research, the number of individuals in each “context” depends on the size of NPHS census tracts’ subsamples included in the surveys.

A study of the distribution of respondents to the longitudinal arms of the NPHS will be needed. It is possible that census tracts’ subsamples are too small for this study. Grouping of census tracts on the basis of both their socio-economic similarities and geographical proximity will be undertaken. A clustering procedure will be helpful in this endeavor.

Three data files are required for the analysis: 1) a file containing the merged data from the 1994 NPHS and the 1996 census tracts data, grouped on the basis of their similarity in socio-economic characteristics; 2) a file containing the merged data from the 1996 NPHS and the 1996 census tracts, similarly grouped if needed; and 3) a file with the respondents to the longitudinal arm of the NPHS merged with their census tracts data, grouped, if needed.

b) Individual-level variables model

Individual-level variables have been selected according to the stress or social support model of health (Cohen and Syme, 1985). Stress is defined in this study as a potential consequence of events or social position that affect an organism’s capacity to cope (Aneshensel, 1992; Antonovsky, 1985). Social support is a counterweight to the negative effect of stress on health (Antonovsky, 1985; Vaux, 1988). Social support has

raised interest in the study of health determinants (Berkman, 1984; Folkman, 1984; Cohen and Wills, 1985; Thoits, 1982; Cohen, 1988; Pearlin, 1989; Wortman and Conway, 1991; Landreville and Cappeliez, 1992; George, 1996). Social support and mortality were correlated in a number of studies (Orth-Gomér and Johnson, 1987; Seeman et al, 1987, 1993; House et al, 1988; Hirdes and Forbes, 1992), while the association of social support with morbidity is less clear (Clarke et al. 1992; Hibbard and Pope, 1993; Iliffe et al., 1992; Marottoli et al., 1994; Seeman et al., 1993). Social support is experienced by individuals and can be interpreted in positive or negative terms. Thus, psychosocial factors may help or hinder individual capacities to use social support. Locus of control (Pearlin and Schooler, 1978) and sense of coherence (Antonovsky, 1985) are two such psychosocial factors. Thus, the individual-level model generating health status includes three categories of independent variables: 1) sources of stress; 2) social support; and 3) psychosocial factors. Age and gender are added as exogeneous variables.

Sources of stress are multiple. Stressful events (death of a loved one, loss of a job) and daily hassles are sources of stress. Other sources of stress are linked with the social position of individuals. In this sense, having an occupation classified at the lower end of the social prestige scale may be stressful in itself, lowering self-images. Stress can also be perceptual: the same events can be perceived as more or less stressful by different individuals. Social support is also a multidimensional construct (House and Kahn, 1985; Felton and Shinn, 1992; Barrera, 1986). Three dimensions of social support are considered in this paper: 1) social network composition and characteristics; 2) activities

with social network partners; and 3) perceived social support. Social support is considered a resource available to individuals. However, other resources may also be important in generating health in individuals: education and income are cases in point.

c) Measurement of individual-level variables.

Six indicators of health status are used in this study: restriction in normal daily activities, chronic illness, functional disabilities, depressive symptoms, perceived health, and well-being.

Sources of stress included in the study are: respondent's unemployment, unemployment in the household, number of stressful events, self-perceived stress generated by these events, and occupational status of the respondent. Unemployed are defined as persons seeking work, seasonal unemployed, persons on strike, persons laid off because of temporary closures, and persons looking for a first job. Stressful events are measured with number of actual problems, recent stressful events and stress on the workplace. Occupational status is measured with the Blishen and McRoberts (1976) scale for socio-economic status (SES). Social status imposes self-images and obligations that individuals have to sustain. We are hypothesizing that the lower the social status, the more difficult it is to maintain a good self-image and to assume obligations.

Individuals obtain support from material, cultural and social resources available to them. Household income is a measure of material resources, education is the only cultural

resource considered. Social resources are social networks and social support characteristics. The social network is described by the presence of a spouse or a life companion, number of children, number of family reunions, participation in social activities, and availability of a confidant. Perceived social support is measured using three questions: having someone to count on in difficult times, having someone to help with tough decision and feeling of being loved.

d) Contextual variables

Scores for census tracts where respondents lived are used to measure context characteristics. Eight characteristics are measured with 14 indicators taken from the 1996 Canadian census: 1) distribution of gender measured by proportion of men in census tracts; 2) distribution of age groups; 3) education; 4) proportion of immigrants; 5) family structure measured by proportion of single parent families and proportion of two-parent families; 6) average annual income; 7) working status measured by participation in the labor force and average unemployment; 8) occupational status measured by proportions of professionals, white collar workers, blue collar workers or farm workers.

Contextual variables are grouped in categories parallel to those used to classify individual-level variables. Contextual variables corresponding to sources of stress in individual-level variables are participation in the labor force, average unemployment and occupational status. The proportion of immigrants has been added as an additional contextual variable. Resources are measured with average annual income and education. Social network is represented by family life (single parent families and two-

parent families). Finally, census tract demography is obtained with proportion of males and of young and old persons.

e) Statistical analysis

Dependent variables are continuous or categorical. Multi-level repeated measures model procedures are used to obtain parameter estimates, with consideration for lost cases in the longitudinal follow-up (Goldstein, 1995). The multinomial link function is used to relate categorical dependent variables to individual-level and contextual-level predictors. The linear link function is used with continuous dependent variables.

ML*n* allows for the consideration of two dependent variables simultaneously. This feature will be used to introduce a measurement of lost cases in the longitudinal analysis. Predictors of health status are also used to predict losses attributable to sampling attrition. Finally, the association of lost cases with the health status measurement is estimated. This modeling of 'loss to follow up' allows us to control the effect of sampling attrition on changes in health status through time and individual-level and contextual-level effects on health status changes.

In the case of categorical dependent variables, statistical significance is examined with the Wald test and with differences in the log-likelihood statistics between a model that includes the tested terms and a model excluding these terms. Wald tests are sensitive to the normality assumption. Markov Chain Monte Carlo methods (Goldstein et al.,

1998) are used to examine the behavior of the distribution of contextual variance. In the case of continuous dependent variables, log-likelihood difference tests are used.

For each health status indicator, data analysis is a six step process. First, the changes in health status attributable to individual and contextual levels are estimated, after controlling for loss to follow up. Second, the stress and social support model is examined with individual-level data only to test for its adjustment to the data set, to identify interactions between individual-level variables according to the buffering hypotheses, and to get at potential problems with collinearity and outliers.

Third, differences among contexts in the rate of change in health status may result from a compositional effect; that is, the sum of individual characteristics in contexts is responsible for differences in health status changes over time. This hypothesis cannot be rejected if, introducing individual-level variables, the estimate of variance in health status attributable to contexts becomes undifferentiated from zero in a statistical test. Fourth, a test of the variation, among contexts, in the effect of individual-level variables on health status indicators is set up. The fifth step is a test of significance for the contribution of contextual-level variables in the variation of intercepts among contexts. Interpretation of intercepts differs according to how models are defined. When both dependent and independent variables are continuous, and means of the latter are set to zero, intercepts represent the average individual in the sample. In the last step, interactions between individual-level and contextual-level variables are introduced.

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