Should We Enhance the Commonly Used Deprivation Index for a Regional Context?

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ABSTRACT

BACKGROUND/OBJECTIVES: Versions of deprivation indices have been increasingly used to monitor patterns and magnitudes of inequality in health. For policy-makers, it is of interest to assess whether they need to construct regionally tailored indices, or whether the existing indices perform sufficiently in detecting inequalities in their respective jurisdiction. Few studies have explored the benefits of constructing a more tailored index for a regional context.

METHODS: The study examined, in linear regression models, the proportion of variance (adjusted R^2) explained in age-standardized cardiovascular disease (CVD) incidence rate ratios by an index emulating a now-widely-used multiple deprivation index created in Quebec (INSPQI), and a newly created index for Nova Scotia with additional census variables. The magnitudes of inequality were compared by the differences between mean incidences of most and least deprived groups.

RESULTS: The newly created deprivation index did not explain as well as the INSPQI-like index the community-level variability in CVD incidences. The gap in mean CVD incidences between the most and least deprived groups was somewhat narrower with the new index, indicating that the new index is not necessarily more sensitive to the inequality attributed to community social disadvantages.

CONCLUSIONS: Complicating the indices may not necessarily be of benefit when used for surveillance of population health inequalities. For public health practitioners and decision makers who need to make quick decisions in provisions of services and programs, a generic, well-established deprivation index such as INSPQI can serve well in a regional context.

KEY WORDS: Deprivation indices; population health surveillance; small-area variation analysis; geographic context

La traduction du résumé se trouve à la fin de l'article.

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In health research, the term deprivation represents the level of disadvantage an individual or group may experience in life circumstance compared with a standard of the society to which they belong. Deprivation, particularly socio-economic deprivation, has been shown to be associated with, for example, hypertension,[1,2] coronary heart disease,[3] acquired immune deficiencies,[4] gastrointestinal hemorrhage,[5] Type 2 diabetes,[6] several cancers,[7] limiting long-term illness (any longstanding illness, health problem or disability which limits someone's daily activities or the work they can do, as asked in UK health surveys and Census),[8] and physical mobility.[9]

In Canada, several indices of deprivation have been developed to track inequalities in health and to estimate the contribution of social process to variations in health and disease. For example, the index developed by the Institut national de santé publique du Québec (hereafter called the INSPQI) is a census-based index of material and social deprivation derived from the Townsend's concepts of deprivation,[10] and it has seen widespread use in Quebec and elsewhere.[11-16] Indices such as Vancouver Area Neighbourhood Deprivation Index (VANDIX),[17] the Socio-Economic Risk Index (SERI),[18] and the Ontario Marginalization index (ONMarg)[19] have been developed and applied to various regions in Canada. INSPQI index and ONMarg index have now been extended for use as national scale indices.[20]

Deprivation indices have gained popularity and have started being adopted by local public health efforts seeking to monitor the patterns and magnitude of health inequalities. Thus, it is worth assessing whether an existing deprivation index serves as a good indicator of health inequalities in a particular geographical context. This study attempts to address the questions: would a common, generic deprivation index work sufficiently well in a specific regional context? Or should such an index be tailored to reflect the demographic and social characteristics of the regional population of interest? This question is of great relevance to organizations responsible for health policy and planning activities, particularly as they are routinely charged with prioritizing the allocation of finite resources and services to reduce health inequalities and improve population health, and may not have sufficient time or resources to construct more local measures of deprivation.

There is currently no gold standard to evaluate what level of performance by any deprivation index is "sufficient". We believe it would be helpful to compare the performance of a regionally tailored deprivation index to a commonly used index to detect patterns and degrees of inequalities across the population. By adding

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variables of local or regional relevance, a tailored index may better explain variation in health. However, tailoring indices for regional characteristics bears greater costs, including: expanded data collection, possibilities of missing data, and increased computational requirements.

We hypothesize that tailoring a deprivation index to account for regional characteristics will improve the performance of the index to explain regional variations in health. Performance in this context is the ability to explain the proportion of variance in health outcomes between communities, and to show the difference in the health gap between most and least deprived communities. The size of the health gap equates to the sensitivity of the index to measure inequalities attributed to community social disadvantage.

The geographic context for this study is the province of Nova Scotia. The study compares a multiple deprivation index similar in design to the INSPQI (hereafter INSPQI-NS), and a tailored deprivation index designed to account for local socio-economic, demographic and social patterns. The comparison assesses the ability of each index to explain the variability in incidence rate ratios of cardiovascular diseases (CVD). In Nova Scotia, CVD is the number one cause of hospitalization[21] and accounts for more than 30% of total health care costs.[22] Beyond the comparison of the two indices, this study adds to our understanding of the underlying socio-economic determinants related to health inequalities, as well as their geographic distribution, in Nova Scotia.[23]

METHODS

Deprivation data

The INSPQI-NS and tailored indices of deprivation were constructed using data at the geographical level of "community". The community area units were initially developed for the purpose of public policy development and decision making, designed in consultation with local planning officials to better represent generally perceived community identities. INSPQI-NS is, therefore, generic in the sense that it contains the same variables from the Census data as INSPQI, composed in a similar manner. The test of difference in performance for the two indices in this study was based solely on whether the inclusion of additional variables considered as locally relevant will enhance the performance in question.

At the time of analysis, Nova Scotia was divided into 276 communities, including 20 Aboriginal reserves and 5 protected areas. Nineteen initial candidate variables from the 2001 Census linked to the area level were derived from the Community Counts database. The 2001 Census was used instead of a more recent (2006) census to show that the events represented by the variables preceded the health events (2003-2007). Six variables were required to generate the INSPQI-NS. Material deprivation (including average individual income, proportion of people with no high school diploma, and employment-to-population ratio) represents the relative socio-economic condition of the population across communities. Social deprivation (including proportion of people living alone; people who are separated, divorced or widowed; and single parents) is considered an indication of fragility of the social network[24] and social isolation.[25] There are a few differences in constructing INSPQI-NS and the original INSPQI. Due to data availability at the community level, the proportion of employed in the population for those 25 years of age and older was used instead of employment-to-population ratio (which includes those 15 to 64 years of age), and proportion of people without high school diploma for those 20 years and older was used instead of those 15 years and older. The sizes of communities employed were somewhat larger than Census Dissemination Areas (DAs) used for the original INSPQI.

Table 1. Census Variables Used in INSPQI-NS (Material and Social Domains), and Tailored Index (New Material, New Social Domains)

	Material	Social	New Material	New Social
Average individual income	x		x	
Unemployment	x		x	
No high school diploma	x		x	
Living alone		x		x
Single parents		x		x
Separated/divorced/widowed		x		x
Ratio non-working to working population				x
Proportion older (65+) people				x
Average monthly housing cost			x	
Houses needing major repair			x	
Proportion of renters				x
Average monthly rent			x	
Proportion of movers in the last 5 years			x	

Note: Variables initially considered but not included in the indices are: overcrowding; proportion of immigrants; proportion of Francophones; proportion of people with Aboriginal origin; proportion of people identifying as Black; total minority (combination of the last three groups).

Additional census variables plus the first six variables were considered for inclusion into a modified index to account for more regional characteristics. For example, high ratios of non-working age group to working age group population in some areas of the province are characteristic to rural Nova Scotia, a situation that is more predominant than in other provinces. Aging of the rural population is occurring as many young adults move to urban areas (Greater Halifax or to other provinces), leaving economically dependent age groups behind. Average monthly cost to maintain homes, overcrowded households, and percentage of dwellings needing major repair can be indicators of chronic income challenges and underemployment, experiences that are prevalent in Nova Scotia and not represented well by income and education status observed at one point in recent time. Proportion of persons identifying as Black, Francophones, persons with Aboriginal identity, and immigrants was also considered in order to determine whether the concentration of these groups indicates any disadvantaged social conditions reflected in health (Table 1).

CVD incidence data

CVD incidences between 2003 and 2007 were abstracted based on ICD-10 codes (hypertensive diseases and Ischemic heart diseases [I10-I25]; cardiovascular diseases and diseases of arteries, arterioles and capillaries [I60-I79]; and transient cerebral ischemic attacks [G45]) from the Hospital Discharge Abstract and Physician Billing data. These datasets have been used in previous studies of disease incidence and community variations in health utilization for Nova Scotia.[26,27] Incidence was defined as the first-time contact for any service (family physician, clinic, or hospital) for any of the above conditions. Indirect age standardization was used with the provincial rates from the same data as the standard. Cubic splines[28] were used to estimate age group population for the intercensal years based on four previous census cycles. Age group populations for 2003 though 2007 were aggregated for calculation of the provincial incidence rates.

Table 2a. Results of Linear Regression Models Examining the Effects of Deprivation Factors on Cardiovascular Disease Incidence at Community Level, According to INSPQI-NS, Nova Scotia, 2003-2007

	Coefficients (95% CI)		
	INSPQI-NS (Material Only)	**INSPQI-NS (Social Only)**	**INSPQI-NS (Both Domains)**
Intercept	1.08 (1.02-1.14)	1.08 (1.01-0.14)	1.08 (1.02-1.14)
Material	0.24 (0.17-0.31)		0.23 (0.16-0.30)
Social		0.13 (0.07-0.20)	0.12 (0.06-0.18)
Adjusted R^2	0.15	0.06	0.20

Source: 2001 Census of Canada; Hospital Discharge Abstract Database, Physician Billing data (2003-2007) extracted by Nova Scotia Department of Health and Wellness. The analysis was based on CVD incidences defined in the Method section at community level in Nova Scotia.

Table 2b. Results of Linear Regression Models Examining the Effects of Deprivation Factors on Cardiovascular Disease Incidence at Community Level, According to Tailored Index, Nova Scotia, 2003-2007

	Coefficients (95% CI)		
	Tailored (New Material Only)	**Tailored (New Social Only)**	**Tailored (Both Domains)**
Intercept	1.04 (1.00-1.08)	1.06 (1.00-0.12)	1.04 (1.00-1.09)
New Material	0.15 (0.06-0.24)		0.16 (0.07-0.25)
New Social		0.11 (0.05-0.18)	0.08 (0.03-0.13)
Adjusted R^2	0.04	0.04	0.08

Source: 2001 Census of Canada; Hospital Discharge Abstract Database, Physician Billing data (2003-2007) extracted by Nova Scotia Department of Health and Wellness. The analysis was based on CVD incidences defined in the Method section at community level in Nova Scotia.

Analysis

Two separate factor analyses were conducted to construct INSPQI-NS and a more tailored index of deprivation. Factor analyses are often used to reduce the number of variables into a smaller number of factors, as was done with INSPQI. The six variables included in the INSPQI-NS along with an additional 13 variables were examined for their frequency distributions, and bivariate regression analysis was conducted to examine the association with CVD incidence. Variables with extremely skewed distributions (e.g., proportion of persons identified as Black) and those which did not have significant associations according to the bivariate analysis were excluded. A total of 13 variables were included in another factor analysis. As in the construction of INSPQI-NS, factors that met a commonly used Eigenvalue requirement of greater than 1 were retained.[29]

To compare the two deprivation indices, multivariate linear regression models were applied to examine the proportion of variance in age-standardized CVD incidence ratios explained by each set – both by individual domains and by the combinations of domains. When a response variable involves a count – especially for rare diseases – Poisson regression is often used. However, as CVD is one of the most common chronic conditions, and our data had high incidence counts and a nearly normal distribution, we opted for linear regression. This allowed the use of (adjusted) R^2 values for a straightforward comparison of the proportions of variance explained by the predictors. Adjusted R^2 accommodated for additional domains and sample sizes (as the numbers of communities for analysis change due to missing data) in the models. The factor scores of each community were classified into quintiles, and then the average of quintile scores within each set of index was again reclassified into five (average scores 1 and 1.5 as class 1, 2 and 2.5 as class 2, etc.). The differences between mean CVD incidence ratios between the most and least deprived classes were then compared. All analyses were conducted using SAS (Version 9.1, Cary, NC).

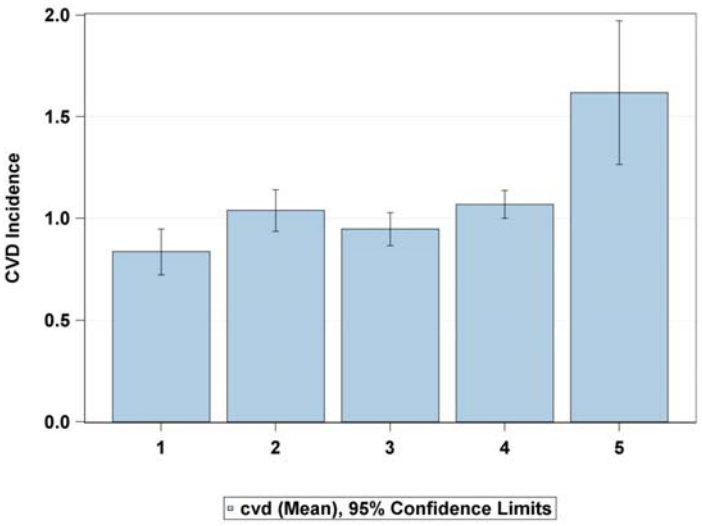
RESULTS

The five protected areas and 11 reserves were excluded from the analysis due to small population sizes. Population sizes of the included communities varied between 400 and 30,000, with an average size of 3,500. Six communities had populations of over 20,000 people. There were 50,228 counts of CVD incidence between 2003 and 2007. The average of the estimated population per year for the five-year period was 910,235. The crude incidence rate was, therefore, about 110 per 100,000 persons per year.

The factor analysis of the six variables involved in the INSPQI in the Nova Scotia context resulted in two factors, accounting for a total of 67% of the total variance in variables and representing two distinct "domains" of social characteristics (material and social). Based on the factor analysis of the 13 variables with the criterion of Eigenvalue >1, again, two factors emerged. Together, they explained about 61% of the variance. The three variables included in the material deprivation in INSPQI-NS and four other variables (housing needing major repair, average monthly rent, proportion of movers in the last 5 years, and average monthly housing cost) were substantially correlated. This factor was termed "new material deprivation". Another factor was named "new social deprivation", and it included the three variables in the social deprivation in INSPQI-NS, and an additional three (ratio of non-working age group to working age group, proportion of people 65 years and older, and proportion of renters). Tables 2a and 2b show the regression coefficients for models examining associations between the age-standardized CVD incidence ratios and the two sets of deprivation index, with adjusted R^2 showing the proportions of variance explained. Models with each domain included at a time showed that the proportions of variance explained by the material and social deprivation in the INSPQI-NS (15% and 6%, respectively), were somewhat higher than the new material and social deprivation in the tailored index (4% and 4%). When both domains were included in a regression model for each set, the overall proportion of variability explained by the tailored index was smaller (8%) than the INSPQI-NS (20%).

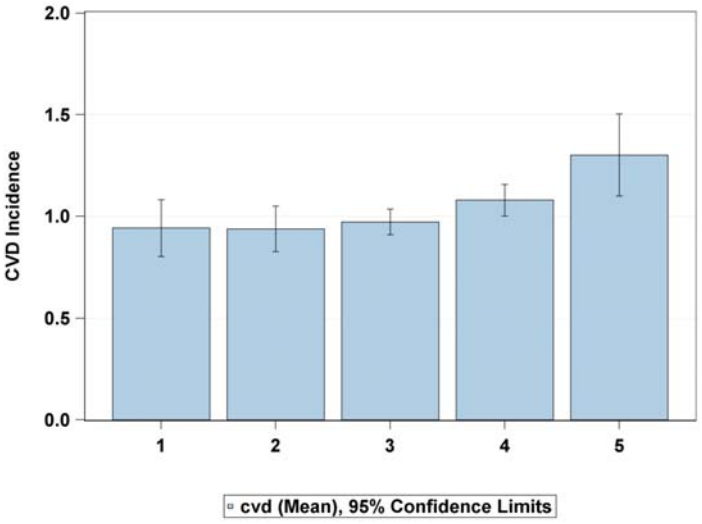
Figures 1 and 2 compare the patterns in the gradient of mean CVD incidence ratios among five classes of average quintile scores between the two sets of deprivation indices. The gradient of mean CVD incidence by the class appears more linear, though flatter, according to the new index, while the gap between the most and

Figure 1. CVD incidence ratios by average quintile score of deprivation (Material and Social domains) measured by INSPQI-NS, Nova Scotia, 2003-2007



Source: 2001 Census of Canada; Hospital Discharge Abstract Database, Physician Billing data (2003-2007) extracted by Nova Scotia Department of Health and Wellness.
Note: Average of quintile scores from the domains were reclassified to 1: average 1 or 1.5 (37 communities), 2: average 2 or 2.5 (58 communities), 3: average 3 (41 communities), 4: average 3.5 or 4 (85 communities), and 5: average 4.5 or 5 (32 communities).

Figure 2. CVD incidence ratios by average quintile score of deprivation (New Material and New Social domains) measured by Tailored deprivation index, Nova Scotia, 2003-2007



Source: 2001 Census of Canada; Hospital Discharge Abstract Database, Physician Billing data (2003-2007) extracted by Nova Scotia Department of Health and Wellness.
Note: Average of quintile scores from the domains were reclassified to 1: average 1 or 1.5 (37 communities), 2: average 2 or 2.5 (52 communities), 3: average 3 (53 communities), 4: average 3.5 or 4 (76 communities), and 5: average 4.5 or 5 (28 communities).

Table 3. Average CVD Incidence Rate Ratios (95% Confidence Intervals) for 5 Classes of Index Scores

	INSPQI-NS	Tailored
Q1	0.84 (0.73-0.94)	0.94 (0.80-1.08)
Q2	1.04 (0.94-1.14)	0.94 (0.83-1.05)
Q3	0.95 (0.87-1.03)	0.97(0.91-1.03)
Q4	1.05 (1.00-1.14)	1.08 (1.00-1.16)
Q5	1.62 (1.27-1.97)	1.30 (1.10-1.50)
Difference (Q5-Q1)	0.78	0.31

least deprived groups was wider with the INSPQI-NS. The risk of CVD incidence of the most deprived class (Class 5) was close to 2 times greater than that of the least deprived class (Class 1) based on the INSPQI-NS, while it was 1.4 times greater based on the new index (Table 3).

DISCUSSION

The aim of this study was to examine how much benefit there would be to construct a tailored deprivation index for the purpose of detecting patterns and magnitudes of health inequalities for a local context compared to using an existing, commonly used index. Toward that aim, the study compared an INSPQI-based index to one incorporating additional variables to account for regional characteristics in the Nova Scotia context. The indices were calculated at the community level and assessed for their predictive ability and sensitivity to inequality of CVD incidence.

The findings do not show support for our hypothesis that the modification of generic, commonly used indices would improve the performance substantially – at least in the context of explaining variations in CVD incidence in Nova Scotia. The gap in incidence of CVD based on the new index between the most and least deprived groups was somewhat narrower, showing that the new index was no more able than the generic index to account for the inequalities attributed to the community social disadvantages.

The current study has some important limitations. First, it was limited to using census data in the construction of the indices. Dependence on administrative data has been pointed out as a weakness in many studies searching for social explanations (or determinants) of health inequalities, as the explanatory factors tend to be chosen based on data availability rather than being theoretically derived.[30] A theory-driven data collection approach in support of constructing deprivation measures will remain elusive until resources can be allocated. In the interim, the Census will continue to be the main source of data for the construction of population-level social and socio-economic indices.

Second, the study only examined cardiovascular disease. It is possible that the modified index is more sensitive to the inequalities in other diseases attributed to community conditions than INSPQI-NS, and the result cannot be generalized for all other diseases. Having said this, though unofficially, we conducted the same analysis using some major categories of mental health outcomes. We found that proportions of variances explained by the generic index in the incidence of alcohol and drug disorders was also higher, suggesting that the relationships are at least not exclusive to CVD.

Third, being a minority in a relatively less diverse society compared with some larger, more populated provinces could have unique implications to health. However, minority groups in Nova Scotia, such as Mi'kmaq (3.7%), Francophones (3.8%) and African Nova Scotian (2.2%) populations, are concentrated geographically, distributed among only a few communities. This skewed distribution made them unsuitable to be included in the regression analysis employed. To understand the factors pertaining to ethnic concentration in Nova Scotia, therefore, it is more viable to take a case study approach wherein these communities with highly concentrated minority groups and several comparison groups are studied for their similarities and differences.[27,31]

Caution should be taken with the finding with respect to the area units employed. The levels of deprivation were calculated at a community level, which is larger than census tract or census dissemination areas often employed to approximate "neighbourhoods".[32] Therefore, each area would likely contain more heterogeneous population characteristics, masking the potential inequalities within the area. However, the area unit was employed with the caveat in mind for two reasons. First, it shows the context of each perceived, coherent "community" entity rather than just compositions of people with the characteristics observed in small areas drawn for administrative purposes. Second, it allows the comparisons across urban and rural areas (i.e., rural and urban "neighbourhoods" may be less comparable with respect to their sizes and functions). Moreover, there is no reason to believe that the results would be reversed because of the choice of this area unit.

Efforts to tailor deprivation indices to incorporate local and regional conditions may have merits. However, the advantages of a generic index cannot be overlooked, particularly in the context of monitoring population health inequalities. First, a generic index is usually simpler, and easier to compute. Including more variables in an index also increases the chance of having more missing data, leading to more communities (or other small area units) for which the scores cannot be calculated. In this study, an additional seven communities were excluded from the regression analysis using the tailored index because of missing data.

Second, having more variables also means that the index is more susceptive to changes in newer censuses, increasing the chance of not having identical variables to replicate the index. Replicability of the indices is critical for the purpose of public health surveillance, which monitors changes in population health statuses and their relationships with key social conditions over time.

Third, a simpler index with fewer variables is easier to interpret. The addition of other factors pointing to material conditions in the new index explained less of the community variation in CVD incidence than the original material deprivation domain in INSPQI-NS. This indicates that the additional variables introduce some nuanced difference in, rather than enhance the same, construct. Moreover, variables such as proportion of movers and proportion of renters are also indicative of residential stability,[20] which could both be attributable to the material and social conditions of communities. The differences, however, are theoretically unclear and cannot be easily interpreted.

Our study provides at least one piece of evidence that complicating an index of deprivation by incorporating more factors pertinent to regional contexts is not necessarily of benefit. Of course, care needs to be taken to consider the advantages and disadvantages of using any indices of health determinants. Depending on the purpose of use, additional variables and indicators may need to be considered. For public health practitioners and decision makers who need to make quick decisions in prioritizing locations of services and programs based on the patterns and magnitudes of inequalities in chronic disease outcomes, a generic, well-established deprivation index such as INSPQI can serve well in a regional context.

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RÉSUMÉ

CONTEXTE/OBJECTIFS : On utilise de plus en plus des versions des indices de défavorisation pour surveiller les grandes tendances dans les inégalités de santé et l'ampleur de ces inégalités. Pour les responsables des politiques, il est intéressant de pouvoir évaluer s'ils ont besoin de construire des indices régionaux ou si les indices existants réussissent suffisamment bien à détecter les inégalités sur leur territoire respectif. Peu d'études se sont attachées aux avantages de construire un indice mieux adapté à un contexte régional.

MÉTHODE : Nous avons examiné, dans les modèles de régression linéaire, la part de la variance expliquée par ces modèles (critère R^2 ajusté) dans les rapports de taux d'incidence des maladies cardiovasculaires (MCV) standardisés pour l'âge avec un indice émulant un indice de défavorisation multiple créé au Québec (l'INSPQI), aujourd'hui très utilisé, et un indice nouvellement créé pour la Nouvelle-Écosse avec des variables supplémentaires du Recensement. L'ampleur des inégalités a été comparée selon les différences entre les incidences moyennes dans les groupes les plus et les moins défavorisés.

RÉSULTATS : L'indice de défavorisation nouvellement créé n'a pas expliqué aussi bien que l'indice semblable à l'INSPQI la variabilité au niveau communautaire dans les incidences de MCV. L'écart dans les incidences moyennes de MCV entre les groupes les plus et les moins défavorisés était un peu plus faible avec le nouvel indice, ce qui montre que celui-ci n'est pas nécessairement plus sensible aux inégalités imputées à la défavorisation sociale des communautés.

CONCLUSIONS : Compliquer les indices n'est pas nécessairement un avantage quand ces indices servent à la surveillance des inégalités de santé des populations. Pour les praticiens et les décideurs de la santé publique qui doivent prendre des décisions rapides sur l'organisation des services et des programmes, un indice de défavorisation général bien établi, comme l'INSPQI, peut très bien faire l'affaire dans un contexte régional.

MOTS CLÉS : indices de défavorisation; surveillance de population; analyse des variations régionales; contexte géographique