Embedding Child Health Within a Framework of Regional Health

Population Health Status and Sociodemographic Indicators

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ABSTRACT

Objective: The description of regional variation in children's health requires regional population-based context. But what is the best way to measure the health of a region's population?

Methods: The use of two indicators is described – one a health status measure and the other a measure of socioeconomic wellbeing. It is well known that the population's premature mortality rate (PMR), the age/sex-adjusted rate of death before age 75 years, is highly related to overall health status of an area's residents. Socioeconomic characteristics of an area's residents are also indicative (and likely causative) of health status differences.

Results: The Socioeconomic Factor Index (SEFI) was developed at the Manitoba Centre for Health Policy, using a Principal Components Analysis of census data. PMR and SEFI are highly correlated (Spearman's correlation coefficient $r=0.85$, $p<0.0001$).

Conclusion: PMR can be used as a surrogate measure for both the health status and socioeconomic well-being of regional populations in Manitoba.

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

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Children live in families, families live in communities, and communities are found within regions. Examining the health of children in isolation from the population groups within which they grow may ignore some of the macro-determinants of child health. Ill health in children is regrettable, but if ill health is looked upon solely as an individual characteristic of the child, then social policy and programming can do little to alleviate the burden of child illness. The question thus becomes – are there determinants of children's health to be found in the socioeconomic well-being and the health of a region's population? If the answer is "yes", then those programs and policies which can influence a population's socioeconomic well-being and health might also influence the health of the region's children.

In order to "embed" child health indicators within a framework of population health, one must first derive measures of a population's health status and socioeconomic well-being. What is the best way to measure this overall health of a region's population? The discussion focuses on the derivation of two population-based regional indicators and the relationship between them – one representing socioeconomic risk, and the other health status. This framework was used throughout this supplement whenever child health data were presented by geographical regions of the province of Manitoba, Canada.

Population-based socioeconomic indicators

A large body of research evidence supports what has been observed for centuries: at the population level, there is an association between socioeconomic status and health. Lower socioeconomic status is associated with poorer health outcomes, and there is a gradient effect such that with each increase in level of socioeconomic status there is an increase in health status.¹ This relationship is referred to as the 'socioeconomic gradient in health status.' Socioeconomic status in childhood is related not only to child health²⁻⁵ but to long-term health outcomes.⁶⁻¹⁰ So global measures of the health and socioeconomic well-being of the regional population wherein a child resides may help in the understanding of child health and well-being.

How, then, should one measure the effects of socioeconomic status on health? There is an extensive history of efforts to identify measures of socioeconomic status to serve as indicators of underlying factors that affect health. Some measures of socioeconomic well-being have relied on single indicators such as income levels, levels of education, and occupational status of the populations in regions.¹¹⁻¹³ For international comparisons, gross national product (GNP) has been used.¹⁴ Carstairs and Morris^{15,16} were interested in a relative deprivation score, based upon four census variables: overcrowding, unemployment among men, low social class, and not having a vehicle. Their deprivation score provided a much more powerful explanation for health differences in Scotland, England and Wales than social class analysis. The deprivation score was highly correlated with all-cause and cause-specific mortality, and a wide range of morbidity data including cancer, mental health, and rates of acute and chronic illness. Although the literature has identified a variety of factors related to health status and health care utilization, no consensus has emerged on either what constitute the best indicators or the exact nature of the causal relationships between various indicators and health status.

In attempting to address health policy issues in Manitoba, the Manitoba Centre for Health Policy (hereafter MCHP) sponsored the development of an indigenous index of socioeconomic status to use in its reports. This was called the Socioeconomic Risk Indicator, or SERI.^{17,18} The index was found to correlate very highly with a variety of health differences and differences in utilization of health care resources across provincial regions.

The SERI was based on data available in Manitoba from census and administrative data files. A set of health status indicators known to be sensitive to socioeconomic status were chosen as a base against which to measure the explanatory power of candidate socioeconomic indicators. These included hospital admissions for injury to females and to males, hospital admissions for children ages 0 through 4 years and for adults more than 65 years old for respiratory infection, and a measure of fertility. An index was constructed by summing these variables after normalisation. Out of

23 candidate socioeconomic indicators derived from public-use census data (1986, and then 1986/1991), six measures were retained in a stepwise multiple regression model against the index described above. The variables that were retained included average dwelling value, educational attainment in one age stratum (25-34), unemployment rates in two age strata (15-24 and 45-54), female single parenthood rates, and rates of female participation in the labour force. A composite socioeconomic index was formed from the weighted sum of standardized forms of the six selected measures, using the regression coefficients as the weights.*

While the SERI was quite robust and intuitively acceptable, it had a substantial disadvantage due to the data-intensive nature of its derivation. It was not easily transportable to other geographical areas, since most other jurisdictions lacked the data to derive the SERI for their own areas. In addition, the use of the SERI as a proxy for determining need for health care use was potentially subject to criticism inasmuch as it had been derived, in part, from utilization data.

In an attempt to correct these deficiencies, three of the authors (NF, KCC, and SD) were commissioned by MCHP to develop an alternative measure of socioeconomic status which would not be subject to the same limitations. This was called the "SEFI", or "Socioeconomic Factor Index", and its derivation is described in this paper.

Population-based health status indicators

There have been many attempts over several decades to obtain global indicators for the health of the population living within a geographical region. Life expectancy at birth, infant mortality, child mortality, mortality rate for ages 15 to 65 ('50Q15'), all cause mortality, self-reported health, disease-specific mortality rates, and low birthweight rates have all been used as surrogates for a global measure of a population's health status.^{11-14,19,20}

In Canada, there has been much discussion of needs-based regional funding for

health care. With that in mind, there has been a call for measures of need based on a health status indicator. Eyles and Birch²¹ voice a number of concerns regarding the attempt to derive a global measure of a population's health status. First, a population's current pattern of health services use may not necessarily reflect their need for health care. Within the province of Manitoba, for example, there are differential use patterns between rural and urban areas, with urban areas accessing physicians more frequently, but rural areas using hospitals more frequently per capita.²² So current measures of service utilization risk the perpetuation of existing availability and accessibility as well as usage patterns. Second, self-reports of population health rely on high-cost surveys, and could be "gameable" – that is, could be influenced by the actions of those who stand to gain by manipulating the data. Thus, self-reported health may best be used as a measure to validate another more easily obtained global measure. Finally, demographic measures such as age, gender and ethnic background are not in and of themselves measures of healthiness, so these indirect proxies may or may not have justification.

Eyles and Birch have argued that measures of premature mortality, such as the PMR (premature mortality rate based on death before the age of 75 years), are more likely candidates for a global measure of a population's health status.^{21,23} First, mortality is a very direct measure of a health outcome, albeit the worst case scenario. Second, mortality data are readily available from administrative data and are collected on a continual basis in a valid and reliable manner. Third, mortality is not affected by patterns of health care use that may not be related to need. Moreover, mortality is not a "gameable" indicator – increasing mortality rates to increase funding for a region is not a likely strategy, besides being completely unethical. PMR, adjusted for the age and gender mix of a population, has been found to correlate with types of morbidity associated with considerable and continual needs for health care. Such conditions include chronic and permanent illness, conditions with high case fatality rates, low birthweight rates, and self-reports of chronic illness.

On the other hand, PMR suffers from a few deficiencies of its own. Early death is a

* In the final form of the index, the sum was divided by the square root of the sum of squares of the regression coefficients to reproduce the scale in standard deviation units, and referred to as the SERI. See MCHP's Concept Dictionary at <http://www.umanitoba.ca/centres/mchp> for full details.

Statistical Significance:

* - Rate significantly different from Manitoba mean at $p < 0.05$

S - Rate significantly different from mean for Rural South Manitoba at $p < 0.05$

Figure 1. Premature mortality rates by RHA, 1994/95-1998/99

TABLE I

Socioeconomic Characteristics from Census Data (1986, 1991, 1996)

Selected for SEFI Derivation

Classification	Variable Definition	Exclusion Reason
Dwelling Characteristics	1. Dwelling Value	Not Defined for On-Reserve (First Nations Community) Households
Education	2. Percent of Population aged 25-34 with High School Diploma or Equivalent 3. Percent of Population aged 35-44 with High School Diploma or Equivalent 4. Percent of Population aged 45-54 with High School Diploma or Equivalent	
Employment	5. Percent Labour Force, Farming 6. Percent Labour Force, Managerial/Sciences 7. Percent Labour Force, Manufacturing/Construction/Transportation 8. Labour Force Participation Percent, Women aged 15+ 9. Unemployment Rate, Aged 15-24 10. Unemployment Rate, Aged 25-34 11. Unemployment Rate, Aged 35-44 12. Unemployment Rate, Aged 45-54	Proxy for Urban/Rural Differences Proxy for Urban/Rural Differences Proxy for Urban/Rural Differences
Income	13. Average Household Income 14. Percent of All Households in Owner-Occupied Dwellings 15. Percent Owner-Occupied Household with Costs $\geq 30\%$ of Income 16. Percent of all Tenant-Occupied Household with Costs $\geq 30\%$ of Income	Not Defined for On-Reserve (First Nations Community) Households Not Defined for On-Reserve (First Nations Community) Households Not Defined for On-Reserve (First Nations Community) Households
Mobility	17. Percent In-migrants, within Canada	Not Applicable to Health Status
Social Characteristics	18. Age Dependency Ratio 19. Percent Single Parent Household with Children 20. Percent Female Single Parent Household with Children 21. Percent Female Parent, aged 15-24 22. Percent French Mother Tongue 23. Percent Native Mother Tongue	Not Present on 1991/1996 Census Not significant in regression models and not significantly associated with the first two principal components Proxy for Native/Non-Native (First Nations/non-First Nations) Differences

The number of socioeconomic characteristics were further reduced to 7 variables by combining the 4 age-specific unemployment rate variables (variables 9 through 12) and the 3 age-specific education rate variables (variables 2, 3 and 4) into a single unemployment principal component factor and a single education principal component factor.

relatively infrequent event, and in smaller population aggregates, the PMR is subject to considerable variation from year to year. Hence it either requires a sufficiently high level of aggregation so that the variance from year to year makes it reliable, or several years of data to produce a more stable measure. Each of these deficiencies can prove problematic in certain analytic situations. In addition, PMR is an outcome measure and, although it may be an indicator of health status, it cannot, by any stretch of the imagination, be deemed to be in any way causative.

METHODS

Derivations, methodology, and comparison of PMR and SEFI

Premature Mortality Rate (PMR)

The PMR is an age- and sex-adjusted rate of premature death, that is, death before the age of 75 years, calculated as the number of deaths to residents ages 0 through 74 years old, divided by the total number of residents 0 through 74 years residing in that region. This rate was standardized to reflect the age and sex structure of the overall Manitoba population on December 31, 1996. PMR was calculated for each of the geographical divisions of the province and was based upon a five-year average from 1994/95 to 1998/99, to ensure stability of the measure. The mortality data were derived from Vital Statistics files. Figure 1 shows the PMR by Regional Health Authority (RHA).^{*} The graphs are ordered from the region with the lowest PMR on top and in ascending order of health risk going down the Y-axis. South Eastman RHA had the lowest PMR, and Churchill the highest.

Socioeconomic Factor Index (SEFI)

SEFI was designed on the basis of sociodemographic indicators in publicly available census data. Since comparability with the earlier versions of the SERI was considered desirable, and since changes in SEFI over time would enable the tracking of changes in health status, data were collected from the 1986, 1991, and 1996 censuses. The 23 variables used in deriving

^{*} For corresponding Winnipeg Community Area (Winnipeg CA) graphs, refer to the complete child health report at the MCHP website.

the SERI served as the initial base of sociodemographic variables for possible inclusion in the index. Table I classifies the variables, and the reasons for exclusion of 11 of those variables. From the 12 eligible variables, the number was further reduced to 7 through the use of Principal Components Analysis. The 4 age-specific unemployment rate variables, and the 3 age-specific education rate variables, were each aggregated into a single unemployment principal component factor and a single education principal component factor. This produced 7 socioeconomic “characteristics” – labour force participation of women, average household income, age dependency ratio, percent single parent households, percent female single parent households, and the two aggregated factors of “unemployment” and “education.” In the derivation of the previous index (SERI), it had been found that the average household income variable did not contribute significant additional explanatory power when combined with the other components. For comparison purposes, therefore, a 6-component index excluding the income variable was also constructed.

The derivation of the SEFI was based upon municipal code level data. Within the province of Manitoba for the 1996 census, there were 289 municipalities. A municipal code value for each of the socioeconomic characteristics was required, but the census data were based upon smaller enumeration area values. For any given characteristic, the municipal code level value was calculated using a population-weighted mean of all of the smaller enumeration area values within the municipal code. Missing census information at the enumeration area or municipal code level was imputed an appropriate community average value. Thus each municipal code had assigned to it values for all 7 (or 6) census socioeconomic characteristics. Each of these values was standardized, that is, stated as a comparison to the overall Manitoba average of that characteristic rather than as an actual “real” value. For example, if the labour force participation for women was 20% in municipal code A, and 70% in municipal code B, and the overall mean for Manitoba was 40%, then municipal code A’s value would be -20, and B’s value would be +30.

TABLE II**List of Candidate Socioeconomic Indicators for a Principal Components Analysis**

Indicator	Method of Estimation	Component Characteristics	Municipality Level	Comparison Across Years		
				1986	1991	1996
SPASFLUE	First principal component factor of 6 variable model	A (Age Dep. Ratio), S (Single Parent), F (Female Single Parent), L (Labour Force Part. Female), U (Unemployment Factor), E (Education Factor)	Prop. Cum. Var.*	0.37	0.45	0.41
			Corr. W. Dir PMR†	0.51	0.56	0.63
			Corr. W. 86/91 SERI‡	0.86	0.81	0.75
SOCPC07	First principal component factor of 7 variable model	A (Age Dep. Ratio), S (Single Parent), F (Female Single Parent), L (Labour Force Part. Female), I (Average HH Income), U (Unemployment Factor), E (Education Factor)	Prop. Cum. Var.*	0.40	0.43	0.41
			Corr. W. Dir PMR†	0.50	0.59	0.62
			Corr. W. 86/91 SERI‡	0.86	0.86	0.73

* Proportion of total variance is reported for principal component factors.

† Pearson correlation with direct adjusted PMR

- 1986:N=277. Correlation analysis excludes 3 municipalities with extreme values of direct adjusted PMR

- 1991:N=280

- 1996:N=281

‡ Pearson correlation with 1986/91 composite SERI. All years N=265.

After careful consideration, the first principal component factor of six socioeconomic characteristics (SPASFLUE) was chosen as the index which best met the theoretical requirements.

Figure 2. SEFI scores (Socioeconomic factor index) by RHA, 1996

The first principal component factors of the 7 (or 6) indices were tested for the proportion of total variance explained, and the correlations of the indices at the municipal code level with both PMR and SERI. These are reported in Table II. The average household income component in the 7-factor model did not contribute very much additional variance in the principal component analysis (+0.03, -0.02 and 0, in the 1986, 1991 and 1996 versions)

compared with the 6-factor model. Nor did it consistently increase correlations with the corresponding SERI (0.0, +0.05 and -0.02, in 1986, 1991 and 1996). Hence the 6-factor model was selected as the SEFI.

The SEFI score was calculated at the municipal code level, by using the principal component factor values for each of the six census characteristic values for that municipality. When combining

* The Spearman correlation coefficients are: 0.87 ($p < 0.0001$) for non-Winnipeg RHAs; 0.80 ($p < 0.01$) for Winnipeg Community Areas (Winnipeg CAs); 0.85 overall ($p < 0.0001$)

Figure 3. Socioeconomic factor index (SEFI) versus premature mortality rate (PMR)*

municipal areas into larger aggregates (such as RHAs, Winnipeg and its Winnipeg CAs), the SEFI for each municipal code level within the larger area was weighted by the population of the municipality to derive an overall SEFI for the larger area. For example, the Winnipeg SEFI was calculated as the population weighted sum of the SEFIs of the 14 municipalities which constitute the city. Figure 2 shows the SEFI scores for the RHAs (SEFI scores for Winnipeg CAs are available in the child health report on MCHP's website). The overall Manitoba score is set to "0". So a negative SEFI score indicates *less* risk (more favourable socio-economic conditions), and a positive score indicates *higher* risk compared to the Manitoba average.

The relationship between SEFI and PMR

Over the years for which data were available, the correlations between the SEFI and PMR have been relatively high. In an MCHP report focussing on Winnipeg,²⁴ the Pearson (Spearman) correlation between the SEFI and PMR was: at the Winnipeg CA level 0.98 (0.90); and at a level of further subdivision of Winnipeg neighbourhoods 0.96 (0.80). Figure 3 shows a scatter-plot graph of the relationship of SEFI with PMR values for the RHAs and Winnipeg CAs, with corresponding Spearman correlation coefficients.

DISCUSSION

Embedding child health within population health: Ordering regions by PMR

Since socioeconomic factors are essential to an understanding of the healthiness of regions, the SEFI is one way to indicate the non-medical determinants of health and to estimate where needs for health care are likely to be higher (where there are less favourable socioeconomic conditions). However, there is a high degree of correlation between SEFI and PMR, at all levels of population aggregation. Given the strength of the relationship between PMR and SEFI, it should be clear that the use of PMR not only gives insight into health status and the need for health care, but also, indirectly, into the socioeconomic well-being of the regional population.

As a result of this strong relationship, ordering the graphs by increasing PMR acts as a surrogate for ranking regional populations in terms of decreasing health status, increasing need for health care, and increasing socioeconomic risk. This ordering of regions is followed in figures within this supplement, derived from the child health report,²⁵ and has been used in most other MCHP reports. Hence the reader looking at graphs ordered in this way can use the ordering to ask questions about patterns of health and health care resource use. Which indicators of child health and

resource use follow an "expected" pattern of increase or decrease with the healthiness measure of the region; which do not?

Throughout this supplement, the reader will note that many of the childhood morbidity and mortality indicators, as well as health care use patterns, are strongly related to the regional indicators of health and socioeconomic well-being. There are positive associations of such indicators as infant/child mortality, teen pregnancy, and injury rates with PMR and SEFI. Negative associations, demonstrating decreasing preventive care with increasing risk, are also evident in indicators such as immunization and breastfeeding rates. And then there are the "surprises" or anomalies – those child health indicators that do not show an association with PMR or SEFI, such as low birthweight and preterm rates in non-Winnipeg regions. All of these associations, whether they be positive, negative, or not significant, beg for more research into the causal nature of the associations in order to implement healthy child policy.

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RÉSUMÉ

Objectif : Les écarts régionaux dans la santé des enfants doivent être étudiés dans un contexte régional représentatif. Mais quelle est la meilleure mesure de l'état de santé d'une population?

Méthode : On décrit l'utilisation de deux indicateurs; l'un mesure l'état de santé, et l'autre, le bien-être socio-économique. Comme on le sait, le TMP d'une population donnée – son taux de décès avant 75 ans ajusté selon l'âge et le sexe – est fortement lié à l'état de santé global de cette population. Les caractéristiques socio-économiques des habitants d'une région sont également des indicateurs (et sans doute des facteurs causaux) des écarts dans l'état de santé.

Résultats : À l'aide d'une analyse en composantes principales des données du recensement, le Centre d'élaboration et d'évaluation de la politique des soins de santé du Manitoba a mis au point un « indice des facteurs socio-économiques » (SEFI). Le TMP et le SEFI sont fortement corrélés ($r=0,85$, $p<0,0001$ selon le coefficient de corrélation de Spearman).

Conclusion : Le TMP peut servir de mesure auxiliaire, tant pour déterminer l'état de santé que le bien-être socio-économique des populations régionales du Manitoba.