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MEASUREMENT OF SOCIO-ECONOMIC INEQUALITY USING THE LIFE-QUALITY INDEX

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ABSTRACT. As income inequality presents a narrow view of overall inequality prevailing in a society, the paper focuses on its much broader definition, referred to as socio-economic inequality, which considers the disparities in income as well as in mortality, and standard of living.

The paper presents a new method for measuring the socio-economic inequality using a composite social indicator, Life-Quality Index, derived from two principal indicators of development, namely, the Real Gross Domestic Product per person and the life expectancy at birth. Income inequality and the associated life expectancy variations are integrated into a quality adjusted income (QAI), to account for the observed differentials in life-quality of various quintiles of the population. The Gini coefficient of the distribution of QAI is introduced as a measure of socio-economic inequality.

The proposed approach is illustrated using data on life expectancy of five income quintiles in urban Canada. It is found that the magnitude of inequality in Canada is higher than that reflected by the traditional measure, the Gini coefficient of income.

KEY WORDS: life-quality, life expectancy, Real Gross Domestic Product, inequality, Gini coefficient, income Lorenz curve, human development

1. INTRODUCTION

Traditional measures of income inequality, such as the Gini coefficient, present a narrow view of inequality as they do not account for disparities in health, mortality, living standards, nutrition, and social status across income groups in the society. Inequality with respect to an attribute (e.g., income, mortality) implies a non-uniform distribution of that attribute in the population. The term socio-economic inequality is used in this paper to signify inequality in a broader sense, i.e., inequality with respect to the income, mortality, and standard of living.

Realizing that income inequality is not a true reflection of socio-economic inequality, attention is drawn to other social indicators for its measurement. The life expectancy (LE) at birth is such a

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broad social indicator that encompasses a number of fundamental aspects of social well being that are basic to the overall quality of life experienced by the population (Wilkins, 1980). It is therefore proposed that a measure that integrates the income inequality with inequality in life expectancy would be a more realistic measure of socio-economic inequality among various segments of population.

This paper introduces a new method for measuring socio-economic inequality using a social indicator, namely, the Life-Quality Index (LQI), which is derived from two principal indicators – the Real Gross Domestic Product (GDP) per person, and the life expectancy at birth (Lind, 1993). Considering LE as a summary measure of several life-quality related aspects, e.g., mortality, health, nutrition, and living standards, it is argued that the income adjusted for LE differentials is a surrogate of the income adjusted for life-quality, referred to as quality-adjusted income (QAI). The paper demonstrates the use of LQI to derive quality-adjusted income (QAI) for different quintiles that explicitly accounts for income differentials in life expectancy. It is then proposed that the Gini coefficient of distribution of the quality-adjusted income is a more realistic measure of socio-economic inequality prevailing in a society. The measure of inequality so derived reflects the shortening of life often associated with poor social and economic circumstances, a double disadvantage of poverty. The measure is of further timely interest because the reduction of socio-economic inequality in health has become an explicit objective of the health policy in Canada (Wilkins et al., 1989).

The paper is organized as follows. Firstly, a review of literature on the relationship between income and mortality is summarized, and issues related with the measurement of socio-economic inequality are highlighted. The definition of Life-Quality index and the derivation of quality-adjusted income are presented. Finally, the proposed method is illustrated using Canadian data on income versus life expectancy.

2. INCOME INEQUALITY & LIFE EXPECTANCY: THE LITERATURE

In Canada, as in many other countries, there is a strong evidence of disparities in health status across income groups and other classi-

fication of socio-economic status (Rootman, 1988). Wilkins et al. (1989) documented the changes in mortality by income in urban Canada from 1971 to 1986. The study reported a difference in LE at birth in 1971 between the highest and lowest income quintile of 6.3 years for men and 2.8 years for women. By 1986, these differences had remained substantial but decreased to 5.6 years for men and 1.8 years for women. Another study highlighted that the mortality rate of male in the top 5% income group is about half of that observed in bottom 5% income group (Wolfson et al., 1990). Using the U.S. census data, Kitagawa and Hauser (1973) and Hadley and Osei (1982) also confirmed that income has a definite negative impact on mortality.

Black (1980) showed that, despite more than 30 years of a National Health Service in Britain committed to offering equal care for all, there remained a marked class gradient in standards of health as reflected by wide variation in age-standardized mortality rates (Table I). In terms of life expectancy, Wilkinson (1986a) reported that people in professional occupations were expected to live seven years longer than people in unskilled manual occupations. This amounts to a class-linked disadvantage of about 10% of life expectancy. Comparing social class mortality trends in England and Wales, Koskinen (1985) found that the upper classes have had specially favorable trends in survival from avoidable mortality. Wilkinson (1989) investigated the relationship between the standard of living and mortality differentials and concluded that trends in mortality differences were not related to trends in class differences in average earning, but were strongly correlated to relative poverty.

A close relationship between income inequality as measured by the Gini coefficient and life expectancy has been reported by Wilkinson (1986b) and Rodgers (1979) suggesting that the overall population mortality increases with income inequality. Le Grand (1987) reported negative correlation between the mean age at death and the share of bottom 20% of the population in national income, implying that the higher the share of the poor in national income, the less would be the mortality differentials. Further evidence comes from a study of Kibbutz in Israel by Leviatan and Cohen (1985). They argued for a causal link between the Kibbutz social structure, where class and gender inequality are virtually non-existent, and

TABLE I
Male (age 15–64 years) mortality by social class in England and Wales (Black 1980)

Class	Mortality rate				
	1931	1951	1961	1971	1981
1. Professional	90	86	75	75	66
2. Managerial	94	92	81	81	76
3. Skilled manual & non-manual	97	101	100	104	103
4. Semi skilled	102	104	103	114	116
5. Unskilled	111	118	127	121	166

significantly increased life expectancy and reduced gender difference in longevity.

Interested readers are referred to a recent comprehensive review of literature prepared by Feinstein (1993) on the impact of socio-economic variables on mortality and health.

3. ISSUES RELATED WITH MEASUREMENT OF INEQUALITY

The real size and trend in mortality differentials are important not only because health matters in itself, but also because health serves to indicate the socio-economic conditions in which people live. Though we can quantify changes in access to housing, education, jobs and services, and can also describe some of the wider perhaps less tangible social and physical environment in which people live, we do not know what all these changes add up to in human terms, i.e. quality of life and social well-being. Economic indicators are largely blind to the qualitative changes in the material and social environment crucial to human welfare. Health, on the other hand, is sensitive not only to qualitative changes in the material life but to many psycho-social aspects of life as the accumulating research evidence on stress, boredom, inactivity and depression shows.

The life expectancy at birth is a summary measure of the total mortality experience of a population, and is considered as a basic social indicator for the reasons succinctly stated by Preston et al. (1972): “The circumstances under which men die are closely related to the conditions under which they live. The extent of violence,

poverty, passivity, and ignorance in a population is reflected in the statistics of its causes and ages of death. Vigorous attempts to delay death are so universal that accurate mortality statistics provide a reliable touchstone of population's level of social organization and technological sophistication. Not only do mortality conditions mirror those in the general society, but they also have their own important social implications."

In addition to life expectancy, other common indicators for studying mortality differentials are the standardized morality ratio (SMR), and the age at death. SMR is a limited measure of mortality differentials because it is only concerned with the number of deaths not with the age of death whereas LE certainly depends on the age at which deaths occurs. It is conceivable that two population groups with the same SMR may have different expectations of life (Gaffery, 1976).

Le Grand (1987) proposed the age-at-death as a indicator of mortality that can be attached to individuals in a way that income or wealth holdings are attached. The inequality in such a distribution of age-at-death can be measured by calculating the Gini coefficient. This approach, in essence, measures the variation of mortality within the population as a whole without any reference to the determinants of inequality (Wilkinson, 1986a).

As far as measurement of income inequality is concerned, a vast literature is available on various methods and their merits and shortcomings (Sen, 1973; Love and Wolfson, 1976; Nygard and Sandstrom, 1981). A detailed discussion on these topics is therefore not included in the paper.

It must be stressed that the income or life expectancy alone is not a true measure of socio-economic inequality. A broad measure of inequality is necessary to account for income inequality as well as inequality in health and living conditions reflected by the life expectancy. The idea of using a composite social indicator such as the Human Development Index for measuring the human welfare and the quality of life is gaining popularity (UNDP, 1990). Here, a key, and sometimes controversial, issue is the assignment of weights to the components chosen to construct the composite index (Lind, 1992; Wish, 1986). As the derivation of Life-Quality Index is based on a more logical weighting scheme for its components, it is proposed

as a more preferable tool to quantify the extent of socio-economic inequality.

4. LIFE-QUALITY INDEX (LQI)

Life-Quality Index is a new social indicator developed to indicate quality-adjusted life expectancy (Lind et al., 1992). LQI is an aggregate of two social indicators, a simple function of two reliable and important measures of social development, namely the Real GDP per person and the life expectancy at birth. In LQI, the life expectancy is a measure of health-related quality of life (LE can be adjusted for health states if and when this is a significant factor, Wilkins and Adams, 1983), while the Real GDP per person is a surrogate measure of wealth-related aspect of quality of life. LQI can be seen as a measure of the Real GDP per person but with the duration and health-related quality of life factored in. Or, conversely, it can be viewed as the expected duration of life but adjusted for the level of wealth and health to reflect the quality of life.

The Real GDP per person, b, and LE at birth, e, reflect important aspects of general social well being in a society. The total enjoyment of life may be thought of as having two dimensions, namely intensity and duration. Line (1993) has shown that any product of the form

$$1. \qquad L = b^q e^s$$

is a possible compound indicator of quality-adjusted life expectancy where q and s are constants, respectively, reflecting the importance of GDP and LE in index L. A project, undertaking or policy may have expected impacts δb on b and δe on e that may be assumed infinitesimal. The expected relative impact of δL on L is

$$2. \qquad \frac{\delta L}{L} = q\frac{\delta b}{b} + s\frac{\delta e}{e}.$$

The exponents q and s can be calibrated as follows to reflect the relative importance people place on discretionary time and consumption. Life in an industrial or agricultural society may be divided into two major components, namely, the proportion of life time, $e_w = w \times e$, spent in economic activity through occupational activities, and remaining proportion of (discretionary) time, $e_d = (1 - w \times e)$, where w is the proportion of life spent in economic activity. Follow-

ing Lind's argument in essence, it can be shown that exponents q and s are related as (Nathwani et al., 1996):

3. $q = s\frac{w}{(1-w)}$

To arrive at final expression, we can choose without loss of any generality, $s = (1 - w)$ so that the expression for LQI becomes

4. $L = b^w \, e^{(1-w)}$

The structure of 4. is intuitively appealing: each variable b and e is raised to the power of the associated proportion of time. This approach provides a better weighting scheme for constructing a composite social indicator. In industrial societies, the proportion of life spent in economic activity, w, is approximately 1/6 (Lind, 1993). Lind et al. (1992) showed that the sensitivity of L to minor variations in w is insignificant.

5. QUALITY-ADJUSTED INCOME (QAI)

As discussed earlier, the life expectancy can be considered as a summary measure of the impact of several attributes of life-quality, such as the standard of living, longevity, quality of health care, and nutrition. Therefore, income adjusted for life expectancy differentials can be treated as a surrogate of the income adjusted for life-quality, referred to as quality-adjusted income (QAI) in this paper. In this section, LQI is used as a basis to derive the quality-adjusted income.

Let the average income per person in the five income quintiles be $b_1 \ldots b_5$, and let the average be $\bar{b}$. Denote the life expectancies of these groups by $e_1 \ldots e_5$, and the average by $\bar{e}$. LQI for any income quintile can be calculated as

5. $L_k = b_k^w \, e_k^{1-w} \qquad (k = 1 \ldots 5).$

The average value of LQI can be approximated by

6. $\bar{L} = \bar{b}^w \, \bar{e}^{(1-w)}.$

If we assume that perfect socio-economic equality implies a constant value of LQI across the population groups, i.e., $L_k = \bar{L}(k = 1 \ldots 5)$, it is possible to calculate the income equivalent, δb, of the difference in life-quality, $(L_k - \bar{L})$, that an individual experiences in a quintile. In other words, δb attempts to quantify, in economic terms, the differences in life quality among various income groups. The income that people in any quintile should be enjoying in order to bring their life-quality index to the average level in the society can be estimated using 6. For example, for a quintile with income b_1, this level of income can be calculated as

$$7. \qquad (\bar{b} + \delta b_1)^w \; e_1^{(1-w)} = \bar{L} = \bar{b}^w \; \bar{e}^{(1-w)},$$

such that an income equivalent of the difference in life-quality in a quintile with life expectancy e_1 would be

$$8. \qquad \delta b_1 = \bar{b}\left(\frac{\bar{e}}{e_1}\right)^{\frac{(1-w)}{w}} - \bar{b}.$$

This quality will be negative for any group that has greater than average LE. The quality-adjusted income (b_1') may now be estimated as the difference between the actual income and the income equivalent of life-quality differential. Thus

$$9. \qquad b_1' = b_1 - \delta b_1.$$

When data on income versus life expectancy are available, the quality adjusted incomes can be easily calculated from eqns. 8. and 9.

5.1 *Measuring Inequality by the Gini Coefficient*

The Gini coefficient is the most widely known and used summary measure of income inequality, perhaps because of its simple geometric relation to the Lorenz curve showing the relationship between cumulative income share and the population share. The Gini coefficient is defined as the ratio of the area enclosed between the line of equality (see Figure 1) and the Lorenz curve to the triangular region underneath the line of equality. This measure, bounded between 0 and 1, has many desirably properties, namely anonymity, continuity, scale independence, and satisfies the principle of transfer implying

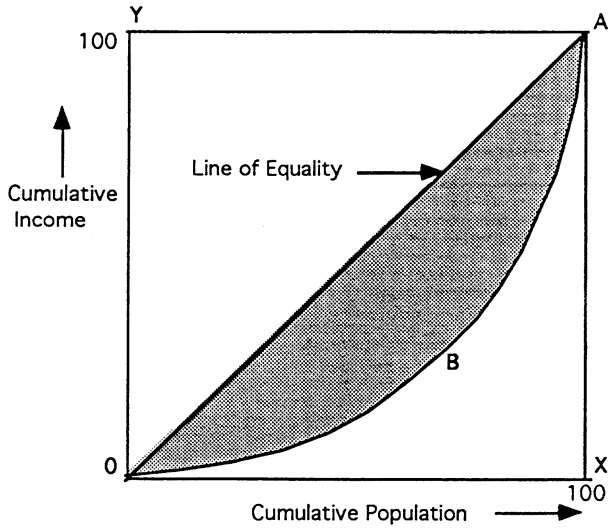

Figure 1. Definition of the Gini coefficient (Gini = shaded area OBA / traiangle area OXA).

that a transfer of income from the richer to poorer person always reduces the magnitude of inequality (Love and Wolfson, 1976). As perfect income equality (uniform income for all) is approached, the Gini coefficient approaches zero whereas under perfect inequality, defined as a single unit receiving all the income and the rest nothing, its value would be one.

Sen (1973) pointed out that the Gini coefficient, G, implies a welfare function which is a weighted sum of different people's income levels. The weights are determined by the rank order of respective income levels when all incomes are arranged in a descending order. Thus, if N is the total number of people and y denotes their income level, then

$$10. \qquad G = 1 + \frac{1}{N} - \frac{2}{N^2 \bar{y}} [y_1 + 2y_2 + 3y_3 + \ldots Ny_N] \quad (\text{for } y_1 \geq y_2 \geq \ldots \geq y_N).$$

If we define δy_k as the difference of people's income, y_k, from the average income, $\bar{y}$, (i.e., $\delta y_k = \bar{y} - y_k$) the Gini coefficient may then be interpreted as a weighted sum of these income differentials arranged in a descending order:

11. $$G = \frac{2}{N^2 \bar{y}} \sum_{k=1}^{N-1} (N-k)\delta y_k$$
(for $\delta y_1 \leq \delta y_2 \leq \delta y_3 \leq \ldots \delta y_{N-1}$).

The lower bound of the Gini coefficient can be estimated from 10. or 11. assuming that the income distribution within an income quintile is uniform and is equal to the quintile average. An upper bound value of the Gini coefficient can be approximately calculated assuming that inequality within a quintile is maximum (Nygard and Sandstrom, 1981: pp. 297).

6. RESULTS

The proposed methodology is illustrated using the data presented by Wilkins et al. (1989) on deaths observed in about 60% of Canada's population living in Census Metropolitan Areas (CMAs). Income quintiles were constructed on the basis of incidence of incomes below the Statistics Canada low-income cut-off in a neighbourhood (or census tract). Although the study was based on neighbourhood rather than individual or family income, the pattern of disparity in mortality between socio-economic groups is likely to be a reasonable approximation of what might be expected in the individual level of analysis. Data in Table II on average quintile income-after-tax for families and individuals are taken from Statistics Canada (1991). After-tax income results from adding cash government transfer payment to the income mainly generated from work and investment and subtracting income tax paid. It should be noted that the cash transfer payment is a major source of income for a lower income family. Data on life expectancy vs. income for year 1978 were obtained from Wilkins and Adams (1983).

Calculations of the quality-adjusted incomes for Canada (1986) are illustrated in Table III. The quintile shares of the actual and quality-adjusted income for years 1971 and 1986 are displayed in Figures 2 and 3, respectively. The distribution of QAI is more unequal than the income distribution as seen from Figures 4 or 5 where the cumulative distribution of income versus population, also known as the Lorenz curve, is plotted. This fact is also reflected by the Gini coefficient of QAI which, for example, is approximately 0.38 for year 1986, higher than 0.33, the Gini of actual income distribution (Table 4). Lower and upper bounds for the Gini coefficient

TABLE II
Canadian data on income versus life expectancy (Wilkins et al. 1989)

Income quintile	Income per person (1991 CAN$)			Life expectancy (years)		
	1971	1978	1986	1971	1978	1986
Q1 poorest	6223	8143	9708	72	71.9	74.
Q2	17060	20470	20237	74.4	73.8	76.9
Q3	27055	32587	31214	74.6	74.7	77.5
Q4	37094	45166	44140	75.9	75.5	78.1
Q5 richest	61061	73317	73026	76.6	76.4	78.5

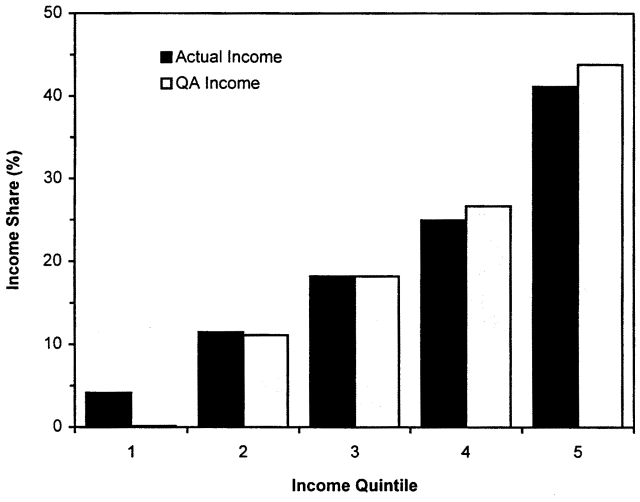

Figure 2. Actual and quality-adjusted (QA) income shares in Canada in 1971.

are computed using the formulas reported by Nygard and Sandstrom (1981). It should be stressed that socio-economic disparities in this approach are certainly understated by the heterogeneous nature of income and mortality within any income quintile. The present results confirm the observation (Wilkins et al., 1989) that disparity in mortality in Canada due to income differentials appears to be reduced from 1971 to 1986.

TABLE III
Calculation of the quality-adjusted (QA) income (Canada, 1986)

Income quintile	Income/person (1991 CAN$)	Life expectancy (years)	Income equivalent of LE differential	Quality-adjusted income	QA income share
1	9708	74.8	5993	3715	0.021
2	20237	76.9	607	19630	0.111
3	31214	77.5	−775	31989	0.180
4	44140	78.1	−2095	46235	0.262
5	73026	78.5	−2942	75968	0.428
Average	35665	77			

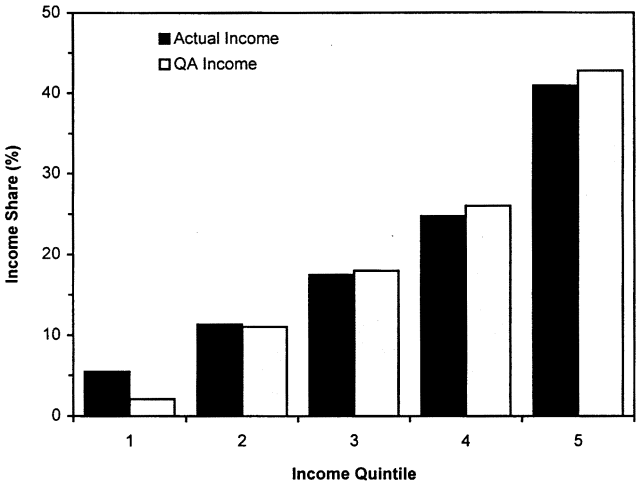

Figure 3. Actual and quality-adjusted income shares in Canada in 1986.

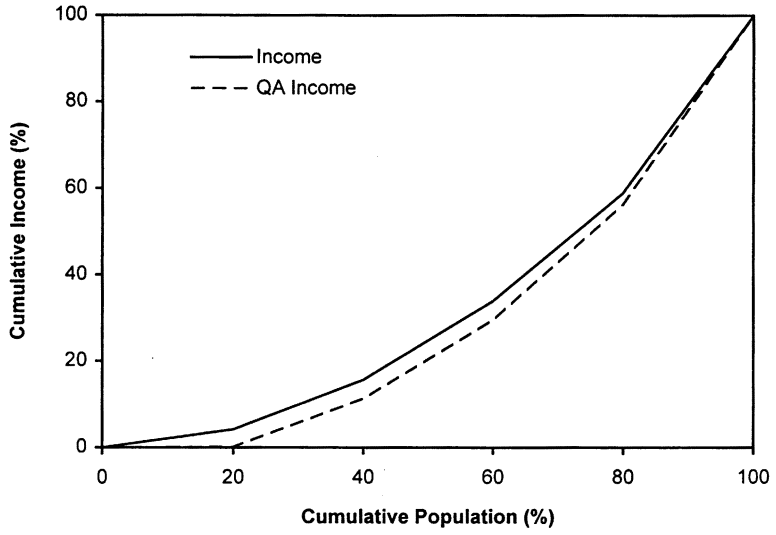

Figure 4. Actual and quality-adjusted (QA) income distribution in Canada in 1971.

7. CONCLUDING REMARKS

The paper considers a broader definition of inequality in the society, referred to as socio-economic inequality, which signified inequality with respect to the income, mortality, and standard of living. The

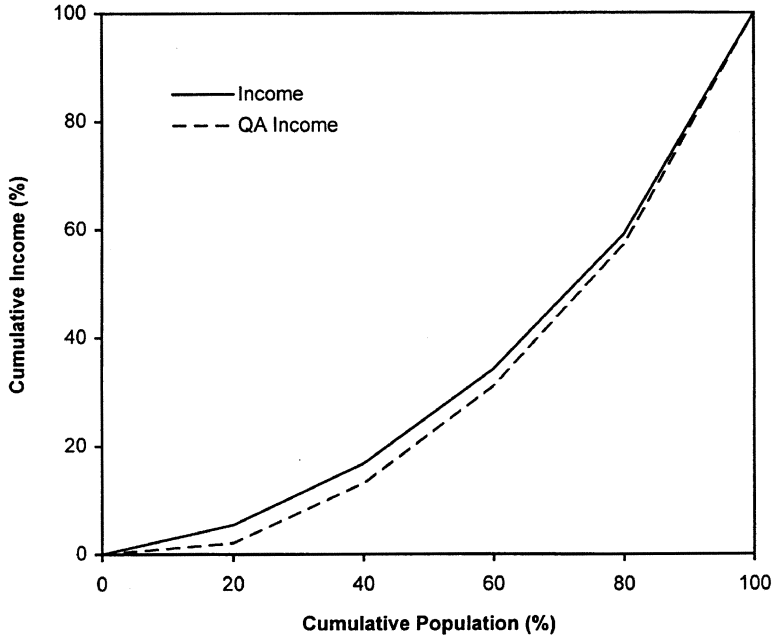

Figure 5. Actual and quality-adjusted income distribution in Canada in 1986.

TABLE IV
Gini coefficient of the income distribution for Canada

Year	Actual income distribution		Quality-adjusted distribution	
	Lower bound	Upper bound	Lower bound	Upper bound
1971	0.3494	0.4103	0.4112	0.4733
1978	0.3452	0.4053	0.4067	0.4695
1986	0.3377	0.3984	0.3855	0.4485

issue of size and trend of socio-economic inequality is crucial, not only to health policy planning but to understanding of the direction of modern social development. Since traditional measures of income inequality are inadequate to quantify the actual extent of socio-economic inequality, it is proposed that a social indicator sensitive to life-quality related aspects would be more suitable for this purpose.

The paper presents a simple method for measuring socio-economic inequality utilizing a composite social indicator, Life-Quality Index, which is derived from two principal indicators, namely, the Real GDP per person and the life expectancy at birth.

In the proposed approach, income inequality and the associated life expectancy differentials are integrated into a quality adjusted income that accounts for the observed differentials in life-quality of various quintiles of the population. The Gini coefficient of QAI is introduced as a more realistic measure of socio-economic inequality than the conventional Gini coefficient of income. This approach is illustrated using data on life expectancy of five income quintiles in urban Canada. It is shown, for example, that the magnitude of inequality in Canada is higher than what is reflected by the Gini coefficient of the income distribution.

This measure of inequality serves as a reminder that the shortening of life associated with poor social and economic circumstances amounts to a double disadvantage to the poor. This approach would benefit from further validation and may prove useful in international and inter-regional comparison of socio-economic inequality.

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