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Age, SES, and Health:
A Population Level Analysis of Health Inequalities over the Life Course

Steven Prus

SEDAP Research Paper No. 181

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April 2007

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Age, SES, and Health:
A Population Level Analysis of Health Inequalities over the Life Course

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Abstract

This paper tests two competing hypotheses on the relationship between age, SES, and health inequality at the cohort/population level. The accumulation hypothesis predicts that levels of SES-based health inequality and consequently overall health inequality within a cohort progressively increase as it ages. The divergence-convergence hypothesis predicts that these inequalities increase only up to early-old age then decrease. Data from a Canadian national health survey are used in this study, and are adjusted for SES-biases in mortality. Bootstrap methods are employed to assess the statistical precision and significance of the results. The Gini coefficient is used to estimate change in the overall level of health inequality with age and the Concentration coefficient estimates the contribution of SES-based health inequalities to this change. Health is measured using the Health Utilities Index and income and education provide the measure of SES. First, the findings show that the Gini coefficient progressively increases from 0.048 (95% CI: 0.045, 0.051) at ages 15-29 to 0.147 (95% CI: 0.131, 0.163) at ages 80+. Second, the data reveal that health inequalities between SES groups (Concentration coefficients for income and education) tend to follow a similar pattern of divergence. Together these findings provide support for the accumulation hypothesis. A notable implication of the study's findings is that the level of health inequality increases when compensating for age-specific socio-economic differences in mortality. These selective effects of mortality should be considered in future research on health inequalities and the life course.

Keywords: Health Inequality; Life Course; SES; Gini/Concentration coefficient.
JEL Classifications: C10, I10

Résumé
Cet article examine deux hypothèses concurrentes sur le rapport entre l'âge, le statut socio-économique (SSE), et les inégalités liées à la santé de différentes cohortes de la population. L'hypothèse d'accumulation prédit que le niveau des inégalités sociales de santé et par conséquent l'inégalité globale de la santé au sain d'une même cohorte augmente progressivement avec l'âge. L'hypothèse de « divergence-convergence » prédit que ces inégalités augmentent seulement au début de la vieillesse et diminuent ensuite. Cette étude repose sur les données d'une enquête nationale canadienne de la santé ajustées pour les biais attribuables au SSE sur la mortalité. Nous utilisons des méthodes de bootstrap pour évaluer la précision et la significativité statistique des résultats présentés. Le coefficient de Gini est utilisé pour estimer la variation avec l'âge du niveau de l'inégalité globale de la santé et le coefficient de concentration détermine la part de cette variation due aux inégalités de la santé attribuables au SSE. La santé est mesurée par des indices de l'état de santé et le revenu et l'éducation fournissent une mesure du SSE. Nos résultats montrent une augmentation progressive du coefficient de Gini de 0.048 (ci de 95% : 0.045, 0.051) chez les sujets âges de 15-29 à 0.147 (ci de 95% : 0.131, 0.163) chez les sujets âgés de plus de 80 ans. De plus, les données indiquent une évolution comparable des inégalités liées la santé entre les différents groupes socio-économiques (coefficients de concentration pour le revenu et l'éducation). L'ensemble de ces résultats semblent supporter l'hypothèse d'accumulation. Une implication notable des résultats rapportés dans cette étude est que le niveau de l'inégalité de la santé augmente une fois que l'on compense pour les différences socio-économiques de la mortalité spécifiques à l'âge. Ces effets de sélection attribuables à la mortalité devraient être considérés par les travaux de recherche futurs portant sur les inégalités liées à la santé et au cours du cycle de vie.

Background

SES and Health

The inverse relationship between SES (socio-economic status) and morbidity and mortality is well-documented. In a ground-breaking study on health inequality, the Black Report demonstrated that SES is closely linked to health status in the U.K. (Townsend and Davidson 1982), and subsequent research supports this finding (e.g., Acheson 1998, Benzeval and Judge 2001, Ecob and Davey Smith 1999, Townsend *et al.* 1992, van Rossum *et al.* 2000). A strong association between SES and health has also been documented in many other countries including the U.S. (e.g., Adler *et al.* 1994, Lantz *et al.* 2001, McDonough *et al.* 1997, Pappas *et al.* 1993, Schnittker 2004, Williams 1990) and, despite universal access to essential health care, Canada (e.g., Frohlich and Mustard 1996, Hay 1988, McLeod *et al.* 2003, Roberge *et al.* 1995, Roos and Mustard 1997, Roos *et al.* 2004, Smith and Frank 2005, Veugelers *et al.* 2001, Wilkins *et al.* 1991). Longitudinal-based research also shows that the relationship between SES and health is particularly one of social causation (i.e., social position affecting health status) as opposed to the opposite (i.e., health selection) (e.g., Chandola *et al.* 2003, Doornbos and Kromhout 1990, Fox *et al.* 1985, Hirdes and Forbes 1989, Lynch *et al.* 1997a, Mulatu and Schooler 2002, Wolfson *et al.* 1993).

Socio-economic inequalities in health reflect differential social circumstances that are divided along social class lines. Studies show that the experiences and exposures that influence health differences between SES groups are related to differences between SES groups in material, cultural, and lifestyle resources (e.g., Davey Smith *et al.* 1994, Dean *et al.* 1995, Lynch *et al.* 1997b, Stronks *et al.* 1996). Research also points to psychosocial resources (e.g., Adler *et al.* 1994, Aneshensel 1992, House 2002, Kessler and Cleary 1980, Lantz *et al.* 2005, Lin and Ensel 1989, Lynch *et al.* 1997b, McLeod and Kessler 1990, Pearlin and Schooler 1978, Stronks *et al.* 1998, Turner and Lloyd 1999).

Segall and Chappell (2000) explain that material factors are the direct effects of SES on health, while lifestyle and psychosocial factors are the indirect effects. Those with higher education, for example, tend to have higher occupational status and earnings and, thus, adequate financial resources to support the purchase of good housing, nutrition, and private health care, all of which are directly tied to better health. SES also influences health indirectly, as position in the socio-economic structure affects psychosocial (e.g., exposure to negative life events and chronic stressors, self-mastery and -coherence, coping skills, and social support) and health-related lifestyle preferences and behaviours (e.g., cigarette smoking, excessive alcohol and refined-food consumption, leisure-time exercise, access/use of preventative health-care services, and acquisition/interpretation of health-education information), which in turn affects health.

Age, SES, and Health: Divergence versus Divergence-convergence

It is also argued that the strength of the relationship between SES and health changes over the life course, as the health of lower and higher SES persons generally declines at different rates. There are two main, competing hypotheses about the relationship between age, SES, and health. It is contended that the relationship between SES and health strengthens (often referred to as either the divergence or accumulation hypothesis) or strengthens then weakens (divergence-convergence hypothesis) over the life course.

The accumulation (i.e., divergence) hypothesis argues that the health of individuals systematically diverges over the life course (Dannefer 2003, Ross and Wu

1996, Singh-Manoux *et al*. 2004); that is, higher SES compared to lower SES persons tend to experience a less rapid decline in health over the life course. Individuals with higher and lower SES generally experience different health trajectories because of the cumulative effects of early-life behaviours (Berney *et al.* 2000, Brunner *et al.* 1999, Holland *et al.* 2000, Ross and Wu 1995, 1996, van de Mheen *et al.* 1998) and psychosocial forces (Marmot and Davey Smith 1997, Marmot *et al.* 1998, Pearlin 1989, Pearlin *et al.* 2005, Siegrist and Marmot 2004) on their health.

Specifically, the cumulative effects of healthier living, coupled with other advantages in economic, social, and psychosocial resources, over the life course help postpone or compress morbidity and disability into a shorter period of the last years of life for persons with higher SES. Individuals with lower SES by contrast tend to experience increasingly poorer health over the life course, which reflects negative cumulative effects of less healthy lifestyles and economic, social, psychosocial disadvantages on their health with age. As health advantages and disadvantages associated with these resources (or the lack of them) cumulate with age, health differences between socio-economic groups grow and the SES-health relationship strengthens.

The divergence-convergence hypothesis, on the other hand, maintains that the health gap between SES groups diverges only up to middle age and early-old age then converges. This pattern reflects socio-economic differences in the extent of exposure to health-related psychosocial and behavioral risk factors and their impact on health at various stages of life (House *et al.* 1990, 1994). House and Robbins (1983) explain that the size of SES differentials in the exposure to psychosocial/behavioural risk factors associated with morbidity and disability are greatest in middle and early-old age. The impact of many of these factors on health is also greatest at these ages as people become more biologically vulnerable to disease and illness as they grow older, and as the lack of social support, mastery, and competence become more challenging with age. Since exposure to risky health behaviours, lack of social support, high stress, low mastery/competence, and other psychosocial risk factors among lower relative to higher SES groups (and their impact on health) are greatest in middle and early-old age, the socioeconomic-based divergence in health should also be largest at this point in the life course.

However, health is less stratified along socio-economic lines (i.e., SES-based gaps in health converge) among old adults. This reflects the fact that SES differences in exposure to psychosocial/behavioural risk factors fade away among old adults, even though their impact on health is still strong. SES differences in exposure to some health risks are much smaller in old age compared to other ages because of extensive public welfare policies (principally Medicare and Social Security) aimed at reducing health-care and economic, and thus health, inequalities in old age, as well as changes in lifestyle (e.g., persons with low SES are more likely to have retired and/or quit smoking and drinking alcohol) (House *et al*. 1994).

Age, SES, and Health: From Individual to Population Level Health Dynamics

Health dynamics occur on two distinct, yet related, levels: an individual level and a population level. Most research on health dynamics, such as that described above, focuses on the individual level of analysis -- it examines the extent to which individuals with early-life health advantages generally maintain their health status relative to those with early-life health disadvantages over the adult life course. Analysis at the population level considers the collective aspects of these individual level processes (e.g., cumulative advantage/disadvantage).

In fact, it is implied by the accumulation model that health dynamics at the population level are a consequence of health dynamics at the individual level. A direct implication of cumulative health advantage and disadvantage for individuals with higher and lower SES respectively (i.e., individual level health dynamics) is that SES-based and thus overall levels of health inequality within a cohort (i.e., population level health dynamics) increase as it ages (Hart *et al.* 1998). Differences in average health status between SES groups and thus inequality in the total distribution of health outcomes therefore widen with age as a result of the more rapid decline in the health of lower compared to higher SES individuals over the life course. By contrast, it is deduced from the divergence-convergence hypothesis that SES-based and consequently overall levels of health inequality increase then decrease as a cohort grows old as the health of lower and higher SES individuals diverges then converges over the later parts of their life course.

The distinction between individual and cohort/population aspects of health dynamics, however, is not often made in the research literature. Further, empirical studies on health trajectories across the life course are almost always done at the individual level. Descriptions of changes in health inequalities over the adult life course at the population/cohort level of analysis are therefore not well-documented. This paper makes a unique contribution to the literature on social epidemiology by applying and testing the accumulation and divergence-convergence hypotheses at the population health level.

Research Questions

The first and primary research question asks: how does the overall level of health inequality within a cohort change as it ages -- does the overall level of inequality in the distribution of health outcomes increase or increase then decrease with age as implied by the accumulation and divergence-convergence hypotheses respectively? Answers to this question, however, do not provide direct insight into the contribution of SES health inequalities (i.e., differences in average health status between SES groups) to overall health inequalities. Hence, a second research question asks: to what extent do SES health inequalities account for overall health inequalities? As suggested by the accumulation hypothesis, an increase in the overall level of health inequality with age is tied to an increase in the SES-based level of health inequality. By contrast, it is implied by the divergence-convergence hypothesis that SES-based (and thus overall) levels of health inequality increase then decrease as a cohort grows old. The first research question therefore seeks to describe the overall level of inequality in the distribution of health outcomes with age and the second research question attempts to verify the extent to which SES health inequalities account for overall health inequalities.

Methods

Data

This study is based on cross-sectional data from the public-use version of the 1994/1995 National Population Health Survey (NPHS), which covers a representative sample of private Canadian households (excluding those on Indian Reserves and Canadian Forces Bases and in some remote areas of Quebec and Ontario). The NPHS collects information on health and illness, use of health services, determinants of health, and demographic and economic characteristics of individuals, and is based on a multistage stratified cluster probability sampling design developed by Statistics Canada. Sample weights, which were adjusted to sum to sample size, are used in all data analyses here to account for unequal probabilities of selection as a result of the multistage sampling design employed in the NPHS.

The household response rate for the 1994/1995 NPHS was 88.7 percent. In each sampled household, some limited information was collected from all household members (n=58,439) and one person, aged 12 years and over, was randomly selected for a more in-depth interview. These in-depth interviews, which are the data used in this paper, were obtained from 17,626 individuals, for a response rate of about 96.1 percent. At the Canada level, these yield a combined response rate of about 85 percent for the 1994/1995 NPHS (Statistics Canada 2005).

This study focuses on the adult life course from ages 15 and over. Age is a categorical variable divided into 5-year intervals in the NPHS, and collapsed here into six age groups: 15-29 (sample size: 4,014), 30-39 (sample size: 3,592), 40-49 (sample size: 2,756), 50-64 (sample size: 2,873), 65-79 (sample size: 2,361), and 80+ (sample size: 591). The age variable in the NPHS data used here is top-coded at 80 years of age to guard against disclosure.

Approximately 800 cases (or four percent of the total sample) contained missing data on the variables (largely the SES -- income and education -- measures) used in this study, but they were randomly scattered through the data. Analysis shows no statistically significant differences between the average health of missing income cases and valid cases (p=0.945), as well as between missing education cases and valid cases (p=0.245).

Missing data are therefore excluded from the analyses reported here. The final sample size is 16,187 persons.

Measuring Health

Health is measured using the widely-used Health Utilities Index Mark 3 (HUI), which is the most comprehensive and global measure of health status in the NPHS. HUI is an index of an individual's overall functional health based on eight self-reported attributes: vision, hearing, speech, mobility, dexterity, cognition, emotion, and pain/discomfort. Respondents are asked up to several questions per attribute (see Appendix A for the entire HUI module for the 1994/1995 NPHS questionnaire) about their usual abilities or day-to-day health.

These attributes are weighted and organized into a single numerical value using a multi-attribute utility theory, based on preference measures for health states derived from an Ontario, Canada community sample survey (i.e., respondents in this survey were asked to rank various health conditions in order of the severity of their impact on one's health). Values, which reflect health utilities, range from about 0 (i.e., utility of being dead or completely unfunctional) to 1 (i.e., utility of being healthy or perfect functional health) in increments of 0.001 (Feeny *et al.* 2002, Furlong *et al.* 2001). For example, a respondent who is near-sighted, yet fully healthy on the other seven attributes, receives a score of 0.973 or 97.3 percent of full health.

More generally speaking, an HUI score of 0.80 or greater indicates very good health while scores below 0.80 indicate moderate or severe functional health problems (Roberge *et al.* 1995). Relatedly, differences of greater than 0.03 between HUI scores are deemed to be unconditionally (clinically) important and meaningful, and differences between 0.01-0.03 may be important in various situations (Drummond 2001, Feeny *et al.* 2002, Grootendorst *et al.* 2000, Schultz and Kopec 2003). Based on the intra-class correlation coefficient, HUI scores also have a test-retest reliability of 0.77 (Feeny *et al.* 2002).

HUI is also highly correlated with other commonly-used indicators of global health such as self-rated health. Humphries and van Doorslaer (2000) show that the level of SES-based inequality in self-rated health is not significantly different than it is in HUI. Lima and Kopec (2005) point out that the HUI is also statistically associated with drug use and hospitalization, and is reactive to changes in health status due to serious illness or disability. They also find a strong relationship between HUI and health-service utilization.

Overall, the HUI provides a rather objective measure of functional limitations and disabilities, and is often considered a measure of individual as well as population health (Roberge *et al.* 1995). The HUI also provides a comprehensive, global measure of health. This is important for this study because the hypotheses used here assume that lower SES persons are more likely to experience a general susceptibility to disease and illness or multiple health problems as opposed to condition-specific health problems. Finally, and importantly, the HUI is one of the few available health measures that are appropriate for use in most measures of inequality since it is based on a continuous scale.

Measuring SES

This study uses a dual-indicator of SES: income and education (occupation is not appropriate for this study since the NPHS excludes previous occupational information for those no longer in the work force such as retirees). A dual-indicator approach is employed since income and education (while highly correlated) have unique characteristics (e.g., unlike income, education does not change significantly over the middle and later life course) and they reflect different aspects of the social class structure (e.g., income is more likely to represent purchasing power, while education better reflects acquisition and interpretation of health information) (e.g., Davey Smith *et al.* 1998, Oakes and Rossi 2003, Winkleby *et al.* 1992). Using both education and income therefore provides a broader measure of SES.

It is argued that conventional measures of SES such as education and current income may be less suitable for old ages than younger ages (Kaplan *et al.* 1987, Matthews *et al.* 2005), and that alternative measures like long-term income (average income over many years) or net worth/total financial assets (which are not available in the NPHS) may better capture the cumulative effects of lifetime SES on health status in old age (Benzeval and Judge 2001, Robert and House 1996). Conventional SES measures, however, are the most commonly used variables in studies of SES and health. Using education and income thus facilities a comparison of this study to other studies that use similar measures of SES and health (e.g., Humphries and van Doorslaer 2000, Wagstaff and Watanabe 2003). Furthermore, as demonstrated by Duncan *et al.* (2002), conventional SES indicators tend to be strongly correlated with health.

Highest level of education obtained is a categorical variable in the NPHS and is rank-ordered here as follows: (1) doctorate, masters, or medical degree; (2) bachelors degree; (3) some university; (4) community college diploma; (5) some community college; (6) trade school diploma; (7) some trade school (or other schooling beyond high school); (8) high school graduate; (9) some high school; (10) elementary or some elementary school; and (11) no schooling. However, the analysis in this study is based on a standardized version of this variable -- education is collapsed into age-specific quartiles to reduce the impact of cohort effects (e.g., young adults are better educated than old adults). Each education quartile represents 25 percent of the cases for a given age. For those aged 15-29, for example, respondents are rank-ordered by education and then divided into four equal groups, where the first quartile (symbolized as Q1) is made-up of 15-29 year-old respondents with the lowest 25 percent of education, the second quartile (Q2) comprises 15-29 year-olds with the next lowest 25 percent of educational attainment, and so on. This procedure is replicated for each age group; hence, every respondent in the sample is assigned to one of four education quartiles based on his/her educational ranking within a particular age group. Table 1 shows the age-specific education quartile thresholds.

Income is based on total annual household income (in Canadian dollars) before taxes and deductions. It is also a categorical variable that is divided into numerous income intervals (e.g., no income; $1-$4,999; $5,000-$9,999; $10,000-$14,999 ….). The standardization process discussed above was repeated for income (i.e., income was collapsed into age-specific quartiles to reduce the impact of cohort effects). Table 1 shows the income quartile thresholds for each age group.

It is also important to note that patterns of age, SES, and health may be influenced by a SES-bias in mortality (Beckett 2000, House *et al.* 1994, Lynch 2003, Wolfson *et al.* 1993). This bias may alter distributions of education, income, and other measures of SES within age groups and consequently how the effect of SES on health is conditioned by age. SES-based health inequalities (as well as overall health inequalities), especially in old age, therefore may be underestimated because a disproportionate amount of those with lower SES have died, leaving a relatively smaller but healthier population of lower status seniors.

To help deal with this challenge the data used in this paper are weighted to compensate for the effects of SES differences in mortality. In particular, Mustard *et al.* (1997) provide estimates of age-specific socio-economic differences in mortality based on a representative sample of deaths that occurred over a two-year period (from June 1986 to May 1988) in the Canadian province of Manitoba. Using the same approach discussed above to standardize household income and highest level of education, they find a statistically significant relationship between mortality and income quartile rank among individuals aged 30-49 and 50-64 and a significant association between mortality and education quartile rank for only those aged 65 and over. The odds of mortality with a one-level decrease in income quartile (e.g., from the fourth quartile to the third quartile) are 1.34 and 1.36 within the 30-49 and 50-64 age groups respectively. The odds of death with a one-level decrease in education quartile among persons aged 65+ are 1.13. Using these odds, the data here are weighted to compensate for these age-specific socio-economic differences in mortality. In addition, the data are also weighted to account for the sampling design discussed above.

Analysis

Two statistical techniques are used to analyze the research questions: (1) Gini coefficient and (2) Concentration coefficient. The Gini coefficient is used to measure the overall level of health inequality within a cohort (i.e., to answer the first question stated above in the Research Questions section). The Concentration coefficient is used to estimate the extent of health inequalities between SES groups, which provides an answer to the second question stated in the Research Questions section.

The Gini coefficient (symbolized here as G) is a summary device that provides a single number measure of relative (as opposed to absolute) inequality. G ranges from zero to one. If everyone had the same health, G would be zero; conversely, if just one individual was healthy and all others unhealthy, the coefficient would be one. Hence, the higher the G, the more health inequality that exists.

The Gini coefficient expresses the degree of inequality in the distribution of HUI as a single number. To elaborate on the Gini-coefficient findings, health quartile distributions are also calculated. In a health quartile distribution persons are ranked according to their HUI score and divided into quartiles, where the first quartile (Q1) is comprised of persons with the lowest 25 percent of HUI scores… and the fourth quartile (Q4) represents those with the highest 25 percent of HUI scores. Each quartile's health share is then calculated by summing HUI scores of all persons in that quartile and dividing this figure by the sum of all HUI scores. By comparing health quartiles across age groups it is possible to see how shares of health have changed between health groups.

The Concentration coefficient (C_B), which is a modified version of the Gini coefficient, is used here to estimate differences in health status between SES groups (i.e., SES-based health inequality) (Wagstaff and van Doorslaer 2004). Two different C_B values are calculated: one for education and one for income. C_B for education measures the contribution of health inequalities between each education quartile to the overall level of health inequality (i.e., G), and C_B for income measures this contribution for income quartiles. Appendix B provides a discussion of the mathematical calculation of G and C_B.

It is common for the Gini (or Concentration) coefficient to be reported without information on its sampling variance (standard error), even though most studies are based on sample data. When this information is provided it is often based on the bootstrap method (Efron and Tibshirani 1993). The bootstrap technique is used here to estimate standard errors and obtain confidence intervals for the Gini and Concentration coefficients. Null hypotheses of no difference between two given coefficients are also tested. Specifically, when the confidence intervals of two coefficients do not overlap with each other at a given level of significance (e.g., 95 percent), the difference between these coefficients is statistically significant at that level (Moran 2005).

The bootstrap method involves repeated random sampling with replacement (i.e., each case has a chance of being selected more than once in each bootstrap sample) from the data at hand. This produces a series of random samples from which the statistic of interest (e.g., Gini coefficient) is computed for each of these bootstrap samples. This process of repeated sampling produces estimates of the standard error and thus confidence interval of the statistic (Walters and Campbell 2004). In the current study, this process is repeated 1000 times and the normal-approximation method is used to produce the 95 percent confidence interval using Stata (StataCorp 2005). Jolliffe and Krushelnytskyy (1999), Mills and Zandvakili (1997), Moran (2005), and Sosa Escudero and Gasparini (2000) provide further information and discussion on statistical inference through bootstrap techniques for measures of inequality.

Results

Overall Health Inequality

The first, primary research question asks: does the overall level of health inequality within a cohort increase as it ages? Table 2, which is graphically presented in Figure 1, provides the data to answer this question -- it shows the Gini coefficient (G) across age groups. These data are calculated before and after adjustments for the SES-bias in mortality.

As expected, inequality rates are higher after these adjustments are made. By “re-introducing” deceased persons with lower SES, and generally poorer health, back into the sample, the overall level of health inequality (G) increases by more than 10 percent (from 0.061 to 0.068) at ages 40-49 for example. Since true levels of health inequalities are likely underestimated by unadjusted data, all results discussed below are weighted for the SES-bias in mortality.

Table 2 also shows that total inequality in the distribution of health increases with age, supporting the accumulation hypothesis. Inequality changes steadily, but moderately, up to ages 40-49. There is then a trend toward even greater dispersion in health outcomes, especially during old age. The overall rate of health inequality increases more than three-fold from ages 15-29 (G = 0.048) to 80+ (G = 0.147).

Table 2 additionally provides the bootstrapped standard error (SE) and 95 percent confidence interval (95% CI) for each Gini coefficient. The standard errors are small relative to their Gini coefficients, indicating that these coefficients are estimated with a high degree of precision. The null hypothesis that two health distributions (i.e., Gini coefficients) are equal can also be assessed with this information. Since none of the confidence intervals for the Gini coefficients overlap with each other, the difference (i.e., increase) in the Gini coefficient from one age group to the next is statistically significant.

Table 3 provides insight into the above findings. First, it reveals that total health inequality (G) primarily reflects the differences in health shares between the bottom and top quartiles. The bottom quartile (i.e., Q1 or those with the lowest 25 percent of HUI scores) is in fact the only group that has a smaller proportion of total health at each age. For example, their share of all health is just 21.7 percent at ages 15-29, yet they constitute 25 percent of this population. This finding is logical since the bottom quartile also represents those with the poorest health.

Second, the findings in Table 3 reveal that the increase in total health inequality observed in Table 2 mainly reflects the decrease in the bottom quartile's (Q1) share of health over the life course. By ages 80+, their share of health drops to just 13.9 percent. The relative situation of the second quartile (Q2) stays almost the same with age. The decrease in health shares for the bottom quartile therefore benefits the top two quartiles (Q3 and Q4), which possess 30.4 percent and 33.6 percent of all health at ages 80+ compared to 26 percent and 27.2 percent respectively at ages 15-29.

SES-based Health Inequality

The overall level of health inequality (G) increases with age as suggested by the accumulation model. It is also suggested that this increase is a consequence of widening health inequalities between SES groups over the life course (i.e., the second research question). To test this assumption Table 4 (displayed graphically in Figure 2) shows the pattern of both between-income group/quartile health inequality (i.e., C_B for income) and between-education group/quartile health inequality (C_B for education) across age groups.

The data in Table 4 again tend to support the accumulation hypothesis. They show that increased heterogeneity in health between both income quartiles and between education quartiles generally parallels the increase in overall health inequality (G) with age reported in Table 2. The level of between-income quartile inequality in absolute terms tends to increase over the adult life course (C_B ranges from 0.002 at ages 15-29 to 0.0111 at ages 80+), but does moderate somewhat during early old age (ages 65-79). Indeed, the difference between all pairs of (C_B for income) values is statistically significant except for the difference in coefficients between ages 50-64 and 65-79. In relative terms, the contribution of income-related health inequality to total health inequality (i.e., C_B as a percent of G) also tends to increase with age. There is a similar pattern for health differences by education.

Discussion

Policy Implications

This paper makes a distinctive contribution to the medical sociology literature by using accumulation and divergence-convergence hypotheses to explain population level health dynamics. At the individual level, the accumulation hypothesis maintains that health disadvantages attached to early-life risky lifestyle and lack of material and psychosocial resources of individuals with lower SES cumulate with age. While morbidity and disability are increasingly experienced by lower SES persons from middle age and onward, higher SES individuals -- who tend to have less exposure to these circumstances -- experience a "compression of morbidity" into a short period at the end of life. The implication of cumulate health advantages and disadvantages for population level health dynamics is that differences in health between SES groups and thus in the overall distribution of health outcomes widen with age.

The divergence-convergence hypothesis also maintains that health disadvantages of lower SES persons associated with less healthy lifestyles and economic, social, psychosocial deficiencies cumulate with age, but that their impact on health are greatest in middle and early-old age. SES differences in exposure to some health risk factors are much smaller in old age because of extensive old-age welfare policies aimed at reducing economic, health-care, and health inequalities, as well as changes in lifestyle, material, and social circumstances of persons with lower SES. Health is therefore less stratified along socio-economic lines in old age.

The findings presented here provide support for the accumulation hypothesis that an increase in the overall level of health inequality with age is tied to an increase in the SES-based level of health inequality. Both SES (C_B) and total (G) health inequality tend to increase hand-in-hand with age.

The accumulation hypothesis does not assume that social policies and programs are completely ineffective at countering health inequalities in later life. Indeed, without such intervention the divergence observed here would certainly be much wider. Cumulative advantage/disadvantage processes, however, outweigh the redistributive function of public health and income programs. This would suggest that to achieve postponement of morbidity and disability for all persons, efforts need to focus more forcefully on, or target, lower SES groups, especially the poorest of the poor and at earlier stages of the life course.

Public policies can help to reduce socioeconomic-based health inequalities, notably in middle and early-old age, by reducing the exposure to and impact of health-related risk factors among lower SES groups. Health promotion policies have potential for compressing morbidity and disability among entire cohorts, and not just those with economic advantage within cohorts. However, many conventional health promotion policies overlook the socio-economic factors that produce the problem at hand. Tobacco-control policies for example are typically aimed at the general population; yet socioeconomic-centered tobacco policies that reflect the economic, cultural, and social/physical environmental factors that underlie the above average smoking rates of lower SES persons must also be considered. Health promotion policies, programs, and services aimed at modifying rates of obesity, exercise, stress, alcohol consumption, and so on should also be responsive to the needs of lower SES persons.

Strengthening public policies aimed at reducing economic inequalities in the total population would also likely change how the relation of age to health varies across socio-economic groups. The widening health gap between SES groups observed here suggests that policies of income redistribution should be targeted at the lowest SES groups. The potential for healthy aging in old age, for example, hinges on economic resources since old-age income security programs help individuals maintain pre-retirement standings of living and prevent poverty, both of which are associated with health (Wolfson *et al.* 1993). Yet seven percent of all Canadian seniors live below the poverty line, with substantially higher poverty rates for females and those living alone (NACA 2005). Increasing absolute income or providing a guaranteed income above the poverty line to the poorest seniors would likely help to smooth inequalities in the overall distribution of health as cohorts enter old age.

Research Limitations and Implications

This paper provides a general theoretical, methodological, and empirical framework for further research on population health dynamics. This research would benefit from long-term longitudinal health data, which are not generally available in Canada.

First, longitudinal health data could establish a causal link between changes in SES-based and overall health inequalities with age. The data used here show that the increase in overall health inequality with age is accompanied by a similar change in health inequalities between SES groups. Longitudinal data could help to verify this link.

Second, it is often difficult in cross-sectional studies, such as the present one, to isolate the effects of cohort and age. While the SES standardization approach employed here helps to reduce the influence of cohort effects, longitudinal data could help to more completely disentangle confounding age and cohort effects.

Third, the data used in the current study show that health inequalities continue to increase at ages 80+. The data used here are top-coded at 80 years of age. Longitudinal data that are not top-coded would make it possible to determine the exact patterns in the health gap between status groups and hence the overall level of health inequality within a cohort during very old age.

However, any future research on age, SES, and health needs to consider the SES-bias in mortality. The findings here show that when compensating for the selective effects of mortality, inequalities in health do change; that is, they increase. This is logical since this approach is equivalent to “re-introducing” deceased persons with lower SES, and generally poorer health, back into the sample. Future research on health inequalities and the life course must consider age-specific socio-economic differences in mortality. True levels of health inequalities between SES groups and their contribution to inequalities in the overall distribution of health would otherwise likely be underestimated.

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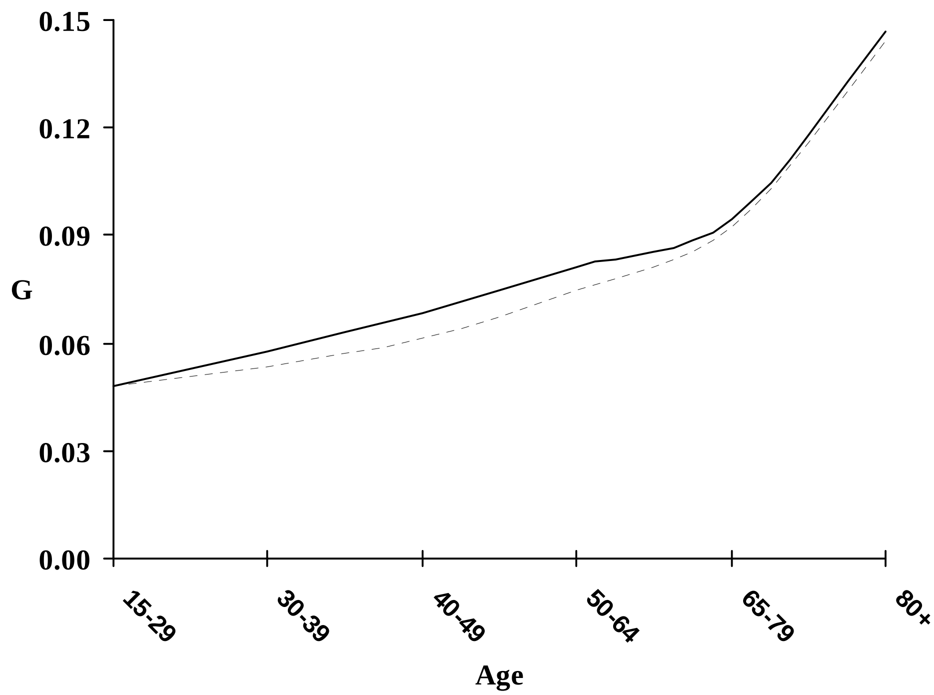
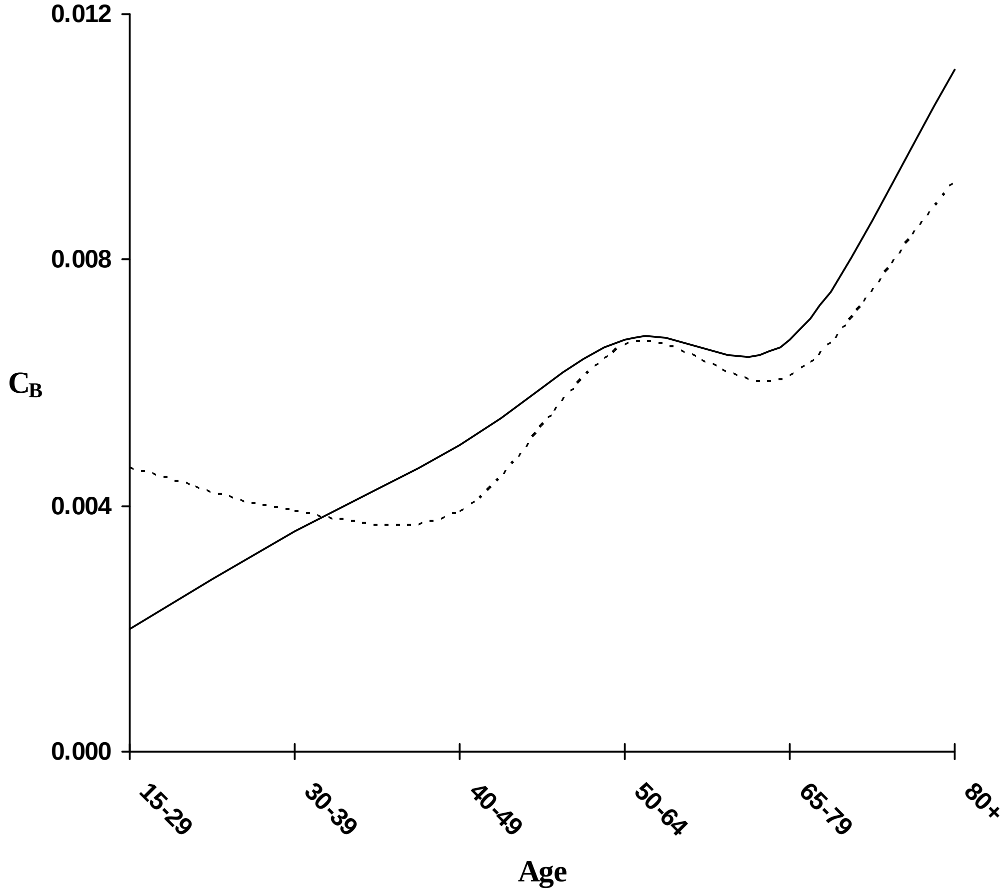
Figure 1: Gini coefficients (G) of HUI Inequality by Age (based on Table 2)



- - - - - - Gini coefficients weighted for sampling design only
———— Gini coefficients weighted for sampling design and the SES-bias in mortality

Figure 2: Between–Income and Between-Education Group/Quartile Concentration coefficients (C_B) of HUI Inequality by Age (based on Table 4) *



—— Income
- - - - - - Education

* Data weighted for sampling design and the SES-bias in mortality

Table 1: Income and Education Quartile Thresholds by Age *

	Quartile Threshold **		
Age (sample size)	**Q1/Q2**	**Q2/Q3**	**Q3/Q4**
15-29 (n=4,014)	20,000-29,999 Some HS	30,000-39,999 Some TS	50,000-59,999 CC
30-39 (n=3,592)	20,000-29,999 Some HS	40,000-49,999 Some CC	50,000-59,999 Some Univ
40-49 (n=2,756)	20,000-29,999 Some HS	40,000-49,999 Some CC	60,000-79,999 Some Univ
50-64 (n=2,873)	20,000-29,999 Some HS	30,000-39,999 Some TS	40,000-49,999 TS
65-79 (n=2,361)	10,000-14,999 Elementary	15,000-19,999 Some HS	40,000-49,999 Some TS
80+ (n=591)	5,000-9,999 Elementary	10,000-14,999 Some HS	20,000-29,999 Some TS

* Income quartile thresholds (in Canadian dollars) are shown in the first row for each age. Education quartile thresholds are shown in the second row, where: Elementary = Elementary School; Some HS = Some High School; Some TS = Some Trade School; TS = Trade School Diploma; Some CC = Some Community College; CC = Community College Diploma; Some Univ = Some University.

** Q1 = persons with the lowest 25 percent of scores… and Q4 = persons with the highest 25 percent of scores.

Table 2: Gini coefficients (G) of HUI Inequality, Standard Errors (SE), and 95 Percent Confidence Intervals (95% CI) by Age *

Age	G	SE	95% CI
15-29	0.048 (0.048)	0.0017	0.045, 0.051
30-39	0.058 (0.053)	0.0018	0.054, 0.062
40-49	0.068 (0.061)	0.0024	0.064, 0.073
50-64	0.081 (0.075)	0.0029	0.075, 0.087
65-79	0.095 (0.093)	0.0034	0.088, 0.101
80+	0.147 (0.144)	0.0081	0.131, 0.163

* Data weighted for sampling design and the SES-bias in mortality (Gini coefficients weighted for sampling design only are in brackets)

Table 3: Share of Total Health (HUI) in Percentages by Health Quartile *

	Age					
Quartile **	**15-29**	**30-39**	**40-49**	**50-64**	**65-79**	**80+**
Q1	21.7	20.9	20.1	18.9	18.1	13.9
Q2	25.1	25.2	25.3	25.5	25.4	22.2
Q3	26.0	26.5	26.6	27.2	27.6	30.4
Q4	27.2	27.4	27.9	28.2	28.8	33.6

* Data weighted for sampling design and the SES-bias in mortality

** Q1 = persons with the lowest 25 percent of HUI scores… and Q4 = persons with the highest 25 percent of HUI scores.

Table 4: Between–Income and Between-Education Group/Quartile Concentration coefficients (C_B) of HUI Inequality, Standard Errors (SE), and 95 Percent Confidence Intervals (95% CI) by Age *

Age	C_B	SE	95% CI
		Income	
15-29	0.0020	0.00005	0.0019, 0.0021
30-39	0.0036	0.00008	0.0034, 0.0038
40-49	0.0050	0.00025	0.0045, 0.0055
50-64	0.0067	0.00011	0.0065, 0.0069
65-79	0.0067	0.00024	0.0062, 0.0072
80+	0.0111	0.00020	0.0107, 0.0115
		Education	
15-29	0.0046	0.00007	0.0045, 0.0047
30-39	0.0039	0.00011	0.0037, 0.0041
40-49	0.0039	0.00018	0.0036, 0.0043
50-64	0.0066	0.00010	0.0064, 0.0068
65-79	0.0061	0.00011	0.0059, 0.0063
80+	0.0093	0.00032	0.0087, 0.0099

* Data weighted for sampling design and the SES-bias in mortality

Appendix A: Health Utilities Index (HUI) Module, 1994/1995 NPHS Questionnaire

The next set of questions asks about day to day health. The questions are **not** about illnesses like colds that affect people for short periods of time. They are concerned with a person's usual abilities. You may feel that some of these questions do not apply to you, but it is important that we ask the same questions of everyone.

Vision

Q1 Are you *usually* able to see well enough to read ordinary newsprint *without* glasses or contact lenses?
___ Yes
___ No

Q2 Are you *usually* able to see well enough to read ordinary newsprint *with* glasses or contact lenses?
___ Yes
___ No

Q3 Are you able to see at all?
___ Yes
___ No

Q4 Are you able to see well enough to recognize a friend on the other side of the street *without* glasses or contact lenses?
___ Yes
___ No

Q5 Are you *usually* able to see well enough to recognize a friend on the other side of the street *with* glasses or contact lenses?
___ Yes
___ No

Hearing

Q6 Are you *usually* able to hear what is said in a group conversation with at least three other people *without* a hearing aid?
___ Yes
___ No

Q7 Are you *usually* able to hear what is said in a group conversation with at least three other people *with* a hearing aid?
___ Yes
___ No

Q7a Are you able to hear at all?
___ Yes
___ No

Q8 Are you *usually* able to hear what is said in a conversation with one other person in a quiet room *without* a hearing aid?
___ Yes
___ No

Q9 Are you *usually* able to hear what is said in a conversation with one other person in a quiet room *with* a hearing aid?
___ Yes
___ No

Speech

Q10 Are you *usually* able to be understood *completely* when speaking with strangers in your own language?
___ Yes
___ No

Q11 Are you able to be understood *partially* when speaking with strangers?
___ Yes
___ No

Q12 Are you able to be understood *completely* when speaking with those who know you well?
___ Yes
___ No

Q13 Are you able to be understood *partially* when speaking with those who know you well?
___ Yes
___ No

Getting Around

Q14 Are you *usually* able to walk around the neighbourhood *without* difficulty and *without* mechanical support such as braces, a cane or crutches?
___ Yes
___ No

Q15 Are you able to walk at all?
___ Yes
___ No

Q16 Do you require mechanical support such as braces, a cane or crutches to be able to walk around the neighbourhood?
___ Yes
___ No

Q17 Do you require the help of another person to be able to walk?
___ Yes
___ No

Q18 Do you require a wheelchair to get around?
___ Yes
___ No

Q19 How often do you use a wheelchair?
___ Always
___ Often
___ Sometimes
___ Never

Q20 Do you need the help of another person to get around in the wheelchair?
___ Yes
___ No

Hands and Fingers

Q21 Are you usually able to grasp and handle small objects such as a pencil and scissors?
___ Yes
___ No

Q22 Do you require the help of another person because of limitations in the use of hands or fingers?
___ Yes
___ No

Q23 Do you require the help of another person with:
___ Some tasks?
___ Most tasks?
___ Almost all tasks?
___ All tasks?

Q24 Do you require special equipment, for example, devices to assist in dressing because of limitations in the use of hands or fingers?
___ Yes
___ No

Feelings

Q25 Would you describe yourself as being *usually*:
___ Happy and interested in life?
___ Somewhat happy?
___ Somewhat unhappy?
___ Unhappy with little interest in life?
___ So unhappy that life is not worthwhile?

Memory and Thinking

Q26 How would you describe your *usual* ability to remember things?
___ Able to remember most things?
___ Somewhat forgetful?
___ Very forgetful?
___ Unable to remember anything at all?

Q27 How would you describe your *usual* ability to think and solve day to day problems?
___ Able to think clearly and solve problems?
___ Having a little difficulty?
___ Having some difficulty?
___ Having a great deal of difficulty?
___ Unable to think or solve problems?

Pain and Discomfort

Q28 Are you *usually* free of pain or discomfort?
___ Yes
___ No

Q29 How would you describe the *usual* intensity of your pain or discomfort?
___ Mild
___ Moderate
___ Severe

Q30 How many activities does your pain or discomfort prevent?
___ None
___ A few
___ Some
___ Most

Source: www.statcan.ca/english/concepts/nphs/quest94e.pdf

Appendix B: Calculating G and C_B

Inequalities in the distribution of health outcomes can be measured both at the univariate or marginal level (i.e., the basic level of health inequality within a population) and at the bivariate or conditional level (i.e., the extent of health inequalities between groups, such as SES groups) (Wolfson and Rowe 2001). The Gini coefficient (G) measures inequality at the univariate/marginal level, and a modified version of the Gini coefficient, often called the Concentration coefficient (C), measures inequality at the bivariate/conditional level.

The mathematical expression for the weighted G (i.e., weighted in this paper to take into consideration the sampling design and the SES-bias in mortality as discussed above) as provided by Crystal and Waehrer (1996), is:

$$G = 1 + \frac{1}{\sum_{i=1}^{k} w_i} - \frac{2\sum_{i=1}^{k}\sum_{j=1}^{w_i}\left(j + \sum_{h=1}^{i-1} w_j\right)h_i}{\sum_{i=1}^{k} w_i \sum_{i=1}^{k} w_i n_i}$$

In this formula let $i = 1,....,k$ index individual observations in the data, where the data are ranked by health (i.e., HUI score) and k is the number of observations. The health (HUI score) and (sample and mortality) weight of the ith observation are denoted by n_i and w_i respectively.

The Gini coefficient is a “pure” or “overall’ (i.e., univariate) measure of health inequality because individuals are ranked by health. However, if individuals are ranked by SES (starting with the most disadvantaged person) as opposed to health, the corresponding Gini coefficient [called the Concentration coefficient (C)] provides a (bivariate) measure of the level of SES health inequality (Wagstaff and van Doorslaer 2004).

If individuals happen to be ranked the same in terms of health and SES, G will also equal C. Any difference in rankings, however, will result in G exceeding C, which is always the case in reality since some persons disadvantaged in SES are advantaged in health and vice-versa. Wagstaff and van Doorslaer (2004) denote the difference between G and C with the symbol R. Overall health inequality (G) is therefore comprised of two parts: C (reflecting the similarity in rankings in the SES and health distributions) and R (reflecting the difference in rankings in the SES and health distributions). Hence, G = C + R.

Wagstaff and van Doorslaer (2004) point out that the above statement assumes that SES is measured on a continuous scale. They offer a similar decomposition of G for categorical SES data (as is the case in the present study). However, a new term is added: $G = C_B + C_W + R$, where C is further decomposed into a between-SES group health inequality term (C_B) [which measures the contribution of health inequalities between each SES group to the overall level of health inequality; i.e., G] and a within-SES group health inequality term (C_W) [which measures the contribution of health inequalities within each SES group to overall health inequality] in a manner analogous to an ANOVA procedure. Specifically, the C_B term shows the level of health inequality if everyone in each SES group receives the mean health score for that group, while C_W reflects the level of health inequality within each SES group.

G and C_B are used here to estimate overall and SES-based health inequality respectively. However, a complete decomposition of G (i.e., C_B, C_W, and R values for both education and income groups/quartiles) is provided below. Further, Clarke *et al.* (2002), Gerdtham *et al.* (1999), Mackenbach and Kunst (1997), Wagstaff *et al.* (1991), Wagstaff and van Doorslaer (1994, 2004), and Waters (2000) provide a detailed discussion of measurements of inequalities in health, namely in terms of the Gini/Concentration coefficient.

Decomposition of Overall (G) HUI Inequality *

Measure of Inequality	Age 15-29	30-39	40-49	50-64	65-79	80+
			Education			
C_B	0.0046	0.0039	0.0039	0.0066	0.0061	0.0093
C_W	0.0122	0.0208	0.0198	0.0291	0.0305	0.0614
R	0.0311	0.0332	0.0442	0.0452	0.0583	0.0763
G	**0.048**	**0.058**	**0.068**	**0.081**	**0.095**	**0.147**
			Income			
C_B	0.0020	0.0036	0.0050	0.0067	0.0067	0.0111
C_W	0.0175	0.0254	0.0295	0.0392	0.0328	0.0413
R	0.0284	0.0289	0.0334	0.0350	0.0554	0.0946
G	**0.048**	**0.058**	**0.068**	**0.081**	**0.095**	**0.147**

* Coefficients weighted for sampling design and the SES-bias in mortality

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