Health, Human Capital and Its Contribution to Economic Growth

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Abstract

This paper proposes a framework that can be used to estimate investment in human capital arising from activities that reduce mortality and morbidity or investment in human capital from health. The measurement framework builds upon and extends Jorgenson-Fraumeni income-based approach for estimating human capital to account for the effect of health on human capital. The paper then implements this framework for Canada and provides an estimate of investment in human capital from health arising from activities (e.g., health, education, on the job training, migration) that improve the life expectancy and reduce mortality rates for the period 1970 to 2020. The paper finds that net investment in human capital from health increased in the 1970s and 1980s, changed little in 1990s and 2000s and declined in the 2010s. Net investment in human capital from health was about 4% to 5% of total net investment in human capital from 1980 to 2010. That share was lower in the 1970s and 2010s. In the 2010s, net investment from health was about 2.8 billion dollars a year and it accounted for 1.4% of net investment in human capital from all sources. The year 2020 saw a large decline in net investment in human capital from health due to increase in mortality rates during the Covid-19 pandemic. The paper also finds that investment in health capital is larger for men than for women after 1970 as the decline in mortality rates was larger for men over the period in that period. The estimate of investment in health human capital from the income approach is found to be lower than health expenditures in Canada. This suggests that much of health expenditures should be classified as consumption rather than investment.

1. **Introduction**

Investment in human capital is a major source of economic growth. It is also the main determinant of individual income. Schultz (1961) introduced the concept of human capital. Becker (1964, 1975) presented a general theory of investment in human capital. In their framework, individuals undertake activities and investment that contribute to the accumulation of human capital. Those activities include health, education, the on the job training, migration (Schultz, 1964 and Becker 1964).

The importance of education and health for human capital is highlighted by World Bank (2018). The World Bank views human capital as the most important component of total wealth globally and provides evidence that supports the view. The concept of human capital by the World Bank is closely tied to health and education. Declines in health are held to reduce human capital, while health or education improvements promise more of it.

In Western countries today earnings are much more closely geared to knowledge than to strength. But in earlier days, and elsewhere still today, strength had a significant influence on earnings (Becker 1964). Moreover, emotional health increasingly is considered an important determinant of earnings in all parts of the world. Health, like knowledge and education, can be improved in many ways. A decline in the death rate and a better diet adds strength and stamina, and thus earning capacity, so does the decline in morbidity in general.

While a significant progress has been made on the measurement of human capital arising from education and training (UNECE, 2016, 2020; Fraumeni, 2021), there has also been important, though more limited process on the measurement of health human capital and its contribution to economic growth. This paper fills the gap.

This paper proposes a framework that can be used to estimate investment in human capital form health improvement arising from decline in mortality and reduction in morbidity. It then implements this framework for Canada and provides an estimate of investment in human capital from health arising from activities that improve life expectancy and reduce mortality rates.

In general, two approaches have been used to measure human capital and health human capital in particular: cost-based approach that can be traced back to Kendrick (Kendrick, 1976) and income–based approach due to Jorgenson and Fraumeni (1989, 1992a and 1992b). In the cost-based approach, health human capital is defined as those expenditures related to the improvement of health that have both market and non-market components over time. To implement the cost-based approach, total expenditures in heath need to be split between investment and consumption (maintenance). Kendrick (1964) used 50-50 split. For the income-based approach, health human capital is estimated as the increase in the lifetime income due to improved heath such as increase in life expectancy and decline in morbidity.

The paper has a number of contributions. First, it argues that Jorgenson-Fraumeni income-based measurement framework can be extended to examine the contribution of health to human capital. Health has two dimensions, one is related to mortality and the other related to morbidity. Those two dimensions are both captured in the extended Jorgenson-Fraumeni framework.

Second, it implements this approach for Canada and estimates investment in human capital from the decline in mortality rates in Canada. To our knowledge, this is the first such estimate of investment in health human capital using the income-based approach.

The rest of the paper is organized as follows. Section 2 summarizes the previous work. Section 3 presents an extended Jorgenson-Fraumeni framework that can be used to estimate investment in human capital from activities that increases life expectancy and reduces morbidity. The section then provides and estimate of heath human capital from decline in mortality for Canada. Section 4 discusses the cost-based estimation and presents total expenditures in health that can be used to estimate investment in human capital from health. Section 5 concludes and discusses future work that includes using that framework to examine the effect of morbidity and investment in human capital from improved heath; and an elaboration of an expanded national accounts that recognizes activities and expenditures related to improvement in health as investment rather than consumption.

2. Previous work on health, income growth and economic growth

Kendrick (1964, 1975) presented a cost-based estimate of human capital from health as part of a broader effort to estimate human capital from child rearing, education, training, health and migration, and to integrate human capital in the national accounts in order to examine the effect of this change on macro aggregates such as gross domestic product, investment, income and wealth. Investment in health capital is found to be large. The cost based estimates are developed in a large number of studies following Kendrick' pioneering work.

There is little work that used the income approach to estimate human capital from health. O'Mahony and Samek (2016, 2021) represented the first major attempt using the income approach. They estimated human capital of individuals with various health status.

In general, the income approach for investment in health will capture monetary returns over future periods from health. The returns are associated with reduction in two factors: mortality (life expectancy), and morbidity (disability and debility). The additions to labor compensation and national income from decreasing mortality as it prolongs working life have been shown to be very great (Murphy and Topel, 2003). Likewise, reductions in time lost at work (and at school) due to illness yield a quantifiable increase in income, although available data on hours lost due to illness are fragmentary. Decreased debility as a result of better health, or, conversely, increased levels of vitality will increase productivity as well as psychological well-being (Kendrick, 1976). The previous studies show that much of the economic effect of health is from the increase in life expectancy. The effect of morbidity is less but is most difficult to measure.

Tompa (2002) surveyed the literature on macro studies on health and economic growth and concluded that between 21 and 47.5% of GDP growth per worker can be explained by improvement in health of population defined as health-related expenditures and increase in life expectancy.

Currie and Madrian (1999) and O'Donell (2015) provided surveys of the literature on the effect of health on employment, hours worked and earning. Those studies provided a useful starting point for estimating heath human capital. The evidence from those studies suggests the effect of better health is mainly on employment rates and hours worked and the effect on hours compensation is less clear.

The previous studies have highlighted the interaction between health and education, two main investment activities for the accumulation of human capital. Much of the development literature on health and economic outcomes explores the role that health plays in changing other measures of human capital. In US data, the model of Restuccia and Vandenbroucke (2013) suggests that life expectancy gains over the last half-century were responsible for a quarter of the increase in education over the same period. The individual simply accumulates more human capital in anticipation of lower future mortality.

3. Income-based approach: An extended Jorgenson-Fraumeni human capital measurement framework

This section presents a measurement framework that extends Jorgenson-Fraumeni income-based approach for measuring human capital that takes into account the impact of health on human capital. The framework can be used to estimate investment in human capital from improvement in health over time that includes the decline in morality (or increased life expectancy) and a decline in morbidity (due to illness, increase mental and physical health). The section then presents an estimate of human capital investment from health improvement using the income-based approach.

The income-based approach for the measurement of human capital was developed by Jorgenson and Fraumeni (1989 and 1992a and 1992b). In that approach, human capital stock is estimated as the expected future lifetime income of all individuals and human capital investment is estimated as increase in human capital stock from various activities such as education, training and health improvement.

This approach treats an individual as embodying capital with a “price” given by their lifetime labour income. The approach to measuring human capital has its foundation in the method used to measure physical capital. For physical assets, asset prices are observed directly from market transactions in investment goods; the user cost of capital is derived using the user cost of capital equation. For human capital, wage rates correspond to the user cost of capital and are observed from transactions in labour markets; lifetime labour incomes correspond to asset prices of tangible capital and are derived by calculating the discounted present value of these wage rates over lifetime.

The Jorgenson-Fraumeni account is extended here to account for the effect of health. Such extended framework serves three purposes:

- improve a measure of human capital by introducing additional heterogeneity;
- provide a measure of investment in health capital, that captures the combined effects of health care, clean air, housing, diet, exercise and other activities; and
- better understand long term economic growth.

The extended framework is used by O’Mahony and Samek (2016, 2021) to estimate health human capital for the UK. The main departure in their extended account of human capital with health status is the explicit accounts of the effect of health status on the lifetime income of an individual.

The two components of Jorgenson-Fraumeni human capital measurement are human capital stock estimation and an accumulation account of human capital and they will be presented in this section. The section follows Gu and Wong (2010).

3.1. Human capital stock

The lifetime labour income for all individuals is estimated using cross-sectional data. It is assumed that expected incomes in future periods are equal to the incomes of individuals of the same gender, education and health, with the age that the individual will have in the future time period, adjusted for increases in real income. The lifetime income can be calculated by a backward recursion, starting with age 74 which is assumed to be the oldest age before retirement. The expected income for a person of a given age is their current labour income plus their expected lifetime income in the next period times survival probabilities. For example, the present value of lifetime income of 74 year old is their current labour income. The lifetime income of 73 year old is equal to their current labour income plus the present value of lifetime income of the 74 year-year-old, adjusted for increases in real income. Formally, we use the following equation for estimating average human capital per capita for a cohort of individuals with gender s, age a, educational attainment e, and health status (w):

(1) $$h_{e,a,w}=w^1_{e,a,w}y^1_{e,a,w}+w^2_{e,a,w}y^2_{e,a,w}+sr_{a,a+1}h_{e,a+1,w}(1+g)/(1+r),$$

where,

$h_{e,a,w}$ = average human capital or average lifetime income per capita for individuals with age a, educational attainment e, and health status w;

$w^1_{e,a,w}$ = probability of engaging in paid employment for individuals with age a, educational attainment e and health status w, defined as the number of paid workers over the population for that cohort;

$y^1_{e,a,w}$ = annual labour compensation of paid workers with age a, educational attainment e and health status w;

$w^2_{e,a,w}$ = probability of engaging in self-employment for individuals with age a, educational attainment e and health status w, defined as the number of self-employed workers over the population for that cohort;

$y^2_{e,a,w}$ = annual labour compensation of self-employed workers with age a, educational attainment e and health status w;

$sr_{a,a+1}$ = the probability of surviving one more year from age a; and

g = real income growth rate;

r = discount rate.

The equation holds separately for males and females.

During their working life, individuals may pursue further education to increase their earnings. To incorporate the extra human capital of those individuals, backward recursion (1) needs to be modified as,

(2)

$$h_{e,a,w} = w^1_{e,a,w} y^1_{e,a,w} + w^2_{e,a,w} y^2_{e,a,w} + (1 - senr_{e,a,w}) sr_{a,a+1} h_{e,a+1,w} (1+g)/(1+r) \qquad + \sum_{m=1}^{M_e} (senr_{e,a,w}/M_e) sr_{a,a+m} h_{e+1,a}$$

,

where,

$senr_{e,a,w}$ =school enrolment rate defined as the proportion of individuals with educational attainment e who are studying for a higher educational attainment e+1; and

M_e = number of years that the individuals with educational level *e* spend to complete a higher educational level *e+1*.

When individuals pursue further studies, they face two possible earnings streams; one with the current educational attainment e, and the other with the higher educational attainment e+1 with a delay due to schooling. Average human capital per capita among a cohort of the individuals is a weighted sum of these two earnings streams, with weights being the probability of school enrolment.

The enrolment rates are allowed to differ by health status to take into account the interaction between health and education.

In equation (2), it is assumed that students enrolled in an educational level are evenly distributed across different study years, except for certain young ages. For example, 18 year-old students studying for a Bachelors degree are assumed to be in their first year. 19-year-old students studying for a Bachelors degree are assumed to be in their second year.

The stock of human capital in current price is the sum of lifetime labour incomes for all individuals in the working-age population. This nominal value of human capital stock can be aggregated into nominal capital stock by gender (e,g. Gu, 2022, Liu, Fraumeni and Managi, 2022, and Fraumeni and Christian, 2019). It can also be aggregated into human capital stock by health status, or by age group and by education levels (O'Mahoney and Samek, 2016, 2021).

The stock of human capital in current price can be decomposed into volume index of human capital stock and price index of human capital stock. In human capital accounts by Jorgenson and Fraumeni, the changes in the average lifetime income of individuals with the same characteristics are the price changes of human capital and the changes in the number of individuals and the composition of individuals with different characteristics are the volume changes of human capital. This approach assumes that there are no changes in the efficiency of individuals with the same characteristics such as age, education and health status. Some recent papers have attempted to relax this assumption (Fraumeni, 2022 and Inklaar and Papakonstantinou, 2020).

More specifically, the volume of human capital stock or the stock of human capital in constant dollars is estimated as Tornqvist aggregation of the number of individuals cross-classified by gender, age, education, health status using weights based on their average lifetime income (for details see Jorgenson and Fraumeni 1989, 1992a and 1992b,. Gu and Wong 2010).

An alternative to this approach for estimating the volume and price index of human capital stock is to assume that change in the price of human capital stock is the same as CPI and other general price index. An implicit assumption for this alternative approach is that the changes in nominal human capital stock over the CPI captures the changes in the efficiency of the human capital stock embodied in the individuals. Wei (2004, 2008) adopted this approach for estimating the volume index of human capital for Australia.

3.2. Human capital investment

The Jorgenson-Fraumeni human capital account also includes an accumulation account of human capital that tracks the evolution of human capital stock over time. In such account, the changes in human capital stock are decomposed into three components: gross investment in human capital, depreciation on human capital, and revaluation of human capital.

Gross investment in human capital is measured by increases in human capital stock from the activities that contribute to an increase in lifetime income that includes increase in population due to the rearing of children and migration, formal schooling, vocational and on-the-job training and health.

The second component of the change in human capital is the depreciation on human capital which is the change in human capital stock due to aging, death and emigration. It can be calculated as the sum of changes in lifetime labour incomes with age for all individuals that remain in the working-age population and lifetime labour incomes of all individuals who leave the workforce, die or emigrate.

The third component of the change in human capital is the revaluation of human capital which represents the change in human capital over time for individuals with a given set of demographic statistics – sex, age, education and health. It can be calculated as the sum of changes in lifetime labour income from period to period for individuals with a given set of demographic statistics.

The derivation of the equation for decomposing the change in human capital stock starts with the definition of human capital stock. Human capital stock in current dollars in period t is the sum of lifetime labour income for all individuals in the working-age population:

(3) $$P_K^t K^t = \sum_{s,e,a,w} h_{s,e,a,w}^t L_{s,e,a,w}^t,$$

where P_K^t is the price index of aggregate human capital stock, K^t is volume index of aggregate human capital stock.

The change in the value of human capital stock from period t-1 to period t may be written as:

$$(4)\qquad P_K^t K^t - P_K^{t-1} K^{t-1} = \sum_{s,e,a,w} h_{s,e,a,w}^t L_{s,e,a,w}^t - \sum_{s,e,a,w} h_{s,e,a,w}^{t-1} L_{s,e,a,w}^{t-1}$$

$$= \sum_{s,e,a,w} h_{s,e,a,w}^t L_{s,e,a,w}^t - \sum_{s,e,a,w} h_{s,e,a,w}^t L_{s,e,a,w}^{t-1} + \sum_{s,e,a,w} \left(h_{s,e,a,w}^t - h_{s,e,a,w}^{t-1}\right) L_{s,e,a,w}^{t-1}$$

$$= \left(\sum_{s,e,a,w} h_{s,e,a,w}^t L_{s,e,a,w}^t - \sum_{s,e,a,w} h_{s,e,a+1,w}^t sr_{a,a+1}^{t-1} L_{s,e,a}^{t-1}, w\right) - \left(\sum_{s,e,a,w} h_{s,e,a,w}^t L_{s,e,a,w}^{t-1} - \sum_{s,e,a,w} h_{s,e,a+1,w}^t sr_{a,a+1}^{t-1} L\right.$$

$$+ \sum_{s,e,a,w} \left(h_{s,e,a,w}^t - h_{s,e,a,w}^{t-1}\right) L_{s,e,a,w}^{t-1}$$

The first term is gross investment in human capital in current prices. The second term is the depreciation of human capital. The third term is the revaluation of human capital stock which is the sum of changes in lifetime labour incomes from period to period for individuals with a given set of demographic statistics – sex, education, age and health.

According to Equation (4), change in human capital is the sum of gross investment in human capital net of depreciation and the revaluation of human capital.

To interpret the term for investment in human capital, we re-write the term as:

(5)

$$\sum_{s,e,a,w} h_{s,e,a,w}^t L_{s,e,a,w}^t - \sum_{s,e,a,w} h_{s,e,a+1,w}^t sr_{a,a+1} L_{s,e,a,w}^{t-1} \qquad = \sum_{s,e,a \subset [15],w} h_{s,e,a,w}^t L_{s,e,a,w}^t + \sum_{s,e,a \not\subset [15],w} h_{s,e,a,w}^t \left(L_{s,e}^t\right.$$

.

The first term in the equation is lifetime incomes of all individuals that reached working age (15 year old). It captures the effect on human capital investment of the rearing and education of children up to age 15. The second term captures the effect of education, health and immigration on investments in human capital. This is estimated as the average lifetime of individuals with education level e and health status w times the number of individuals that graduated with that education e and health status w in a period or immigrated with that educational level and health status.

The term for the depreciation in human capital may be written as:

$$(6)\qquad \sum_{s,e,a,w} h_{s,e,a,w}^t L_{s,e,a,w}^{t-1} - \sum_{s,e,a,w} h_{s,e,a+1,w}^t sr_{a,a+1} L_{s,e,a,w}^{t-1}$$

$$= \sum_{s,e,a,w} \left(h_{s,e,a,w}^t - h_{s,e,a+1,w}^t\right) sr_{a,a+1}^{t-1} L_{s,e,a,w}^{t-1} + \sum_{s,e,a,w} h_{s,e,a,w}^t \left(L_{s,e,a,w}^{t-1} - sr_{a,a+1}^{t-1} L_{s,e,a,w}^{t-1}\right)$$

The depreciation on human capital is estimated as the sum of two terms. The first term is the change in lifetime labour incomes that occurs with age for all individuals that remain in the working age population. The second term is the lifetime labour incomes of all individuals who leave the workforce, die or emigrate.

Net investment in human capital is defined as gross investment in human capital minus depreciation.

Investment in human capital stock in this extended framework can be further decomposed into investment in education, investment in health, and investment from increase in population from migration and child rearing. For example, Jorgenson and Fraumemi (1992) and Gu and Wong (2015) used this framework to estimate investment in human capital arsing from education. Gu

(2022) focused the role of immigration on human capital accumulation. To my knowledge, no previous work has used this approach to estimate investment in human capital from health.

Investment in health in this extended framework is measured by the impact of health improvement on human capital stock from two sources. The first component is the increase in human capital due to the decline in mortality rates. The second component is the change in the composition of population towards the individuals that are healthier (decline in morbidity).

The first component can be estimated using a counterfactual. The human capital stock in the counterfactual is estimated assuming that mortality rates did not change over time and were set to equal to the ones in a previous period. The difference between this counterfactual and actual human capital stock is the increase in human capital due to the decline in mortality rates in the period. This difference represents a net investment in human capital arising from decline in mortality rates. The decline in mortality rates will increase the lifetime income of individuals which is an component of gross investment in human capital. At the same time, the decline in mortality will also reduce the depreciation of human capital due to death. The combined effect is net investment in health capital from decline in mortality rates: the increase in gross investment from declining mortality minus a decline in depreciation from declining mortality.

The second component of health capital investment is from decline in morbidity and it can be estimated using an extended framework that introduces heath status as additional demographic characteristic. O'Mahoney and Samek (2016) implemented this approach for the U.K.

3.3. Estimates for Canada

The main data sources for the estimation include monthly LFS for the period 1976 to 2020 and Census of Population every five years starting from 1975. The LFS and Census are used to develop the matrices of population counts, paid employment, self-employment, school enrolment, and annual labour compensation of paid workers for individual types excluding health status. Such data are constructed for 1976 to 2020.

The estimates of human capital will be provided for the individuals aged 15 to 74 or working age population. Those individuals are cross-classified by 2 genders, 60 ages (15 to 74), 5 educational levels (primary, secondary, post-secondary, Bachelors degree, and Masters degree or above) for a total of 600 groups of individuals.

The data on the number of individuals, paid employment, self-employment and school enrolment are obtained from the Labour Force Survey for the period 1976 to 2020, and obtained from the Census of Populations for the years before 1976.

The data on the annual earnings of paid workers are obtained from the Labour Force Survey for the period 1997 to 2020, as the LFS started to collect data on hourly earnings of paid workers beginning in 1997. For the years before 1997, the hourly earnings are derived from a linear interpolation of the two adjacent Censuses.

The earnings of self-employed workers are not available from the LFS and Censuses. To estimate the annual earnings of self-employed workers, it is assumed that the hourly earnings of self-employed workers are proportional to that of paid workers with the same level of education and experience with scale factor determined by a regression analysis.

The data on annual earnings of paid workers and self-employed workers are all benchmarked to annual labour compensation in the Canadian Productivity Accounts of Statistics Canada. The data thus reflects the annual labour compensation of paid workers and self-employed workers.

The data on survival rates are obtained from "Life Tables, Canada, Provinces and Territories" published by Statistics Canada (Statistics Canada 2016). While education tends to increase survival rates, no such data exists for Canada. It is assumed that the survival rates do not vary across educational levels and depend on age and gender only.

To implement the income-based approach, it is assumed that individuals with 0-8 years of schooling spend 3 years to complete the next education level (some or completed high school). The individuals with some or completed high school spend 2 years to complete some or completed post-secondary education. The individuals with some or completed post-secondary education spend 4 years to complete a Bachelors degree. The individuals with a Bachelors degree spend 2 years to complete a Masters degree or above.

This paper will exclude the value of non-market activities and focus on the human capital embodied in the working-age population aged 15 to 74. This differs from the human capital accounts of Jorgenson and Fraumeni (1989, 1992a and 1992b) which include the value of non-market activities and value of human capital embodied in all individuals.

The average growth rate of real labour income is set equal to labour productivity growth which is 1.7% per year for our estimation period in Canada. The real discount rate is set equal to 5.1%, which is the weighted average of real rates of return to equity and debt or about real rate of return to capital in Canada. Those are the assumptions used in Gu and Wong (2010).

Life expectancy in Canada

Figure 1 presents life expectancy at birth for Canada by gender over the period 1920-1922 to 2020.[1] Life expectancy in Canada has greatly improved since the early 20th century. Life expectancy at birth for men has increased by 20.7 years, from 58.8 years in 1920–1922 to 79.5 years in 2020. During the same period, life expectancy of women increased by 23.4 years, from 60.6 years to 84.0 years.

Life expectancy has historically been lower for men than for women. While the gap was small in 1920–1922 (1.8 years), it reached a high of 7.3 years in 1975–1977 and narrowed to 4.5 years in 2020.

The widening of the gap before 1975-1977 was partly the result of fewer women dying during childbirth. The narrowing of the gap after 1975-1977 was related to the decline in deaths caused by cardiovascular diseases, which generally affect men more than women (Statistics Canada 2016).

This paper will provide an estimate of investment in health human capital for the period 1970 to 2020. For that period, life expectancy has also increased, but at a slower rate compared with that in the period before 1970. For the period after 1970, life expectancy increased more for men than for women. Life expectancy at birth for men has increased by 10.8 years, from 69.6

[1] Life expectancy is estimated for a three year period before 1980. After 1980, it is estimated annually (Statistics Canada, 2016).

years in 1970 to 79.5 years in 2020. During the same period, the life expectancy of women increased by 8.7 years, from 76.6 years to 84.0 years.

In 2020, life expectancy fell by more than half a year in 2020, the largest single-year decline in Canada since national vital statistics started to be collected in 1921. Mortality rates increased for most age groups. This decline in life expectancy and increase in mortality rates from 2019 to 2020 are primarily linked to the COVID-19 pandemic, which started to hit Canada in 2020. Overall, life expectancy, estimated on an annual basis, was 81.7 years in 2020, a decline of 0.6 years compared with the figure in 2019 (82.3). This decline in life expectancy was greater for men (0.7 years) than for women (0.4 years).

Human capital stock

Figure 2 presents human capital stock in billion dollars expressed in 2012 price in Canada. Nominal values of human capital stock is deflated by CPI to derive human capital in 2012 price. In 2020, total human capital stock estimated from the income-based approach was 24.1 trillion dollars in Canada. Human capital stock was 14.2 trillion dollars for men and was 9.9 trillion dollars for women.

Human capital stock was the largest component of Canada's total wealth that comprises of produced capital, natural and human capital (Gu and Wong, 2010). To get an sense how large human capital stock is, human capital stock is compared with GDP in Canada. GDP was 2.0 trillion dollars in 2020 in 2012 price. Therefore, human capital stock in Canada was about 12 times real GDP in 2020.

Over the period from 1970 to 2020, aggregate human capital rose at an annual rate of 5.6% in Canada. The growth was much faster for women compared with men over that period (6.7% per year for women vs. 5.1% per year for men). This was a result of relatively large increases in labour force participation and education levels of women over that period.

Investment in human capital

The objective is to estimate investment in human capital from improvement in health. Investment in human capital from health is just one component of total investment in human capital from all sources. In general, investment in human capital includes any activities that generate income streams for an individual in the future. Those activities and expenditures include: education and training, net migration and health.

Total investment in human capital can be estimated using the decomposition of changes in human capital (Equation 4). The decomposition components - gross investment in human capital, depreciation, revaluation are presented in Table 1. Those nominal estimates are all deflated using CPI to obtain estimates in 2012 price. Gross investment is sum of the two components: the effect of addition to the population aged 15 to 74 in a year, and the effect of increases in education and net immigration. Depreciation is the sum of the effect of aging for all individuals who remain in the population aged 15 to 74 and the loss of human capital due to death and the individuals who reach the age of 75.

Net investment is gross investment minus depreciation, which is presented in Figure 3 along with gross investment and depreciation.

Both the revaluation component and the overall change in human capital exhibit large fluctuations over time, caused by the variations in the rate of change in the average lifetime labour income (Table 1). Most of the short–run change in the value of human capital therefore reflects the revaluation of human capital stock.

Net investment trended upward before 1980 and then changed little before mid-2010s. It increased after mid-1990s. Depreciation changed little before 1990s and started to increase after 1990.

Figure 4 plots the ratio of net investment in human capital to gross domestic product (GDP) in nominal value. The ratio of investment in human capital to GDP declined from 1971 to 1990, and changed little after 1990. The decline in the investment-to-GDP ratio was fastest during the 1970s because of a relatively rapid increase in GDP. The growth in net investment in human capital changed little in that period as shown in Figure 3. The ratio of net human capital investment to GDP was 0.62 in 1971 and it declined to 0.1 in 1990. After 1990, the ratio of net investment in human capital was about 0.1 and changed very little until mid 2010s. After mid 2010s, the ratio of net human capital investment increased until 2019. In 2020, net investment in human capital as a ratio of GDP declined due to increases in mortality rates from the Covid-19 pandemic.

Investment in health human capital

A decline in mortality rates or increase in life expectancy will lead to an increase in the lifetime income of an individual. This increase in lifetime income is a measure of investment in human capital from activities that caused decline in mortality rates.

The increase in lifetime income from the decline in mortality rates between two years is estimated as the difference in the lifetime income of an individual in a year with the mortality rates in that year and the lifetime income of the individuals with the mortality rates set to those in the previous year. The estimated increase in the lifetime income or human capital represents net investment in human capital in a year due to the decline in mortality rates between those two years. This net increase in human capital is the combined effects of two components in the estimation of investment (Equation 4): increase in gross investment from the increase in survival rates and decline in depreciation due to the decline in mortality rates.

The estimates of net investment in human capital from health are presented in Table 2 for all individuals. Net investment in health human capital increased in the 1970s and 1980s, had little changes in 1990s and 2000s. It was 3.6 billion dollars a year in the 1970s, 7.0 billion dollars a year in the 1980s, 8 billion dollars a year in the 1990s and 2000s. Net investment in health human capital declined in the 2010s. In the 2010s, net investment from health was about 2.8 billion dollars a year.

Net investment in human capital from health was about 4% to 5% of total net investment in human capital from 1980 to 2010. That share was lower in the 1970s and 2010s. The year 2020 saw a large decline in net investment in human capital from health.

As shown in Table 3, net investment in health human capital was higher for men than for women for the period after 1970. This reflected a large improvement in life expectancy for men in that period.

The 2020 decline in net investment in health human capital was larger for men then for women as mortality rates increased more for men than for women from the Covid-19 pandemic.

The estimates show that less than 5% of total net investment in human capital was from investment in health human capital from activities that caused the decline in mortality rates. Even when the effect of health human capital investment from changes in morbidity is included, the share of net health human capital investment is expected to be low, as the effect of decline in morbidity on income was often thought to be much less than the effect of decline in mortality rates on income (Becker 2007).

The estimates in this paper show that most of human capital investment is from factors other than health. Those factors include education, training, net migration or rearing of children. Gu and Wong (2010) shows investment in human capital from education was large and is the most important component of net investment in human capital in Canada.

<u>The cumulative impact of decline in mortality rates on human capital stock since 1970</u>

As shown in Figure 1, life expectancy increased dramatically in Canada. Table 4 presents the overall impact of this change in life expectance since 1970 on human capital stock.

To estimate the cumulative effect of the decline in mortality rates from 1970 on human capital in a year, lifetime income or human capital stock was re-estimated using the mortality rates in 1970. The difference between actual human capital stock in a year and human capital stock re-estimated using the 1970 mortality rates represents the effect of the decline in mortality rates from 1970 on human capital in that year.

The estimates in Table 4 are presented for year 2019, the year before the Covid-19 pandemic. The decline in mortality rates increased human capital stock by 774 billion dollars in 2019. The increase was higher for men than for women as a result of the relatively large increase in life expectancy for men than for women in that period. The decline in mortality rates for men increased total human capital stock for men by 587 billion dollars representing a 4.1% increase in human capital stock in 2019. The decline in mortality rates for women increased total human capital stock for women by 187 billion dollars representing 1.9% increase in human capital stock in 2019.

On a per capita basis, the decline in mortality for men increased human capital stock for men by 42 thousand dollars per person in 2019 and the decline in mortality for women increased human capital stock for women by 13 thousand dollars per person in 2019.

<u>The impact of increase in mortality rates on human capital stock during the Covid-19 pandemic</u>

Table 5 examines the effect of the increase in mortality rates in 2020 on human capital by gender in 2020. The increase in mortality rates in 2020 reduced total human capital stock by 76 billion dollars. The decline was larger for men than for women as a result of the large increase in mortality rates for men in 2020. The increase in mortality rates for men reduced total human capital stock for men by 63 billion dollars or 0.4% decline in 2020. The increase in mortality rates for women reduced total human capital stock for women by 13 billion dollars or 0.4% decline in 2020.

On a per capita basis, the increase in mortality rates for men reduced human capital stock for men by 4 thousand dollars per person in 2020 and the increase in mortality for women reduced human capital stock for women by 1 thousand dollars per person in 2020.

4. Cost-based estimates of health human capital investment and health human capital stock

The cost-based approach for estimating human capital and health human capital in particular is similar to the one often used to estimate physical capital stock and flow in the national accounts. This approach estimates the expenditures spent on those expenditure items related to health as investment in health human capital and then accumulates those investment flow to derive human capital stock. The cost-based approach was used by Kendrick (1976) and Eisner (1985) to estimate human capital stock for the United States. Kendrick (1976) included in investments in human capital the following items: the costs of rearing children, expenditure on health and safety, mobility, and education and training.

The starting point for estimating investment in health human capital is data on health expenditures. The System of Health Accounts (OECD et al. 2017) provides a comprehensive account of those expenditures that are internationally comparable.

Total health expenditures as a share of GDP in Canada was presented in Figure 6. Total health expenditure as a proportion of GDP increased from 7.0% in 1975 to 11.6% in 2019. It then increased dramatically in 2020 due to increases in expenditures related to the Covid-19 crisis.

But not all those expenditures represent investment in human capital that contributes to increases in the earnings and the lifetime income. The challenge is to split health expenditures into a consumption-flow (or maintenance) component and an investment-flow component. For example, Kendrick (1976) attributed 50% of expenditures on health as human capital investment and attribute the other 50% to consumption.

Health expenditures were much higher than the estimate of investment in health human capital from the income-based approach. Health human capital investment as a share of GDP was less than one percent while health expenditures as a share of GDP ranged from 7% to 12%. This suggests that much of health expenditures should be classified as consumption rather than investment.

5. Conclusion

Health, together with education and training are important components of human capital. Total expenditures in health accounted for a significant and increasing portion of gross domestic product in most economies. While a significant progress has been made on the measurement of human capital arising from education and training, there has been more limited process on the measurement of health human capital and its contribution to economic growth.

This paper proposes a framework that can be used to estimate investment in human capital form activities and expenditures that reduce mortality and morbidity. The measurement framework builds upon and extends Jorgenson-Fraumeni incomed based approach for measuring human capital to account for the effect of health on human capital.

The paper then implements this framework for Canada and provides a estimate of investment in human capital from health arising from activities that improves life expectancy and reduces mortality rates for the period 1970 to 2020. The paper finds that net investment in health human capital from decline in morality rates increased in the 1970s and 1980s, had little changes in 1990s and 2000s and declined in the 2010s. Net investment in human capital from health was about 4% to 5% of total net investment in human capital from 1980 to 2010. That share was lower in the 1970s and 2010s. In the 2010s, net investment from health was about 2.8 billion dollars a year and this accounted for 1.4% of net investment in human capital from all sources. The paper also finds that investment in health capital is larger for men than for women as the decline in mortality rates was larger for men than for women over that period after 1970. The year 2020 saw a large decline in net investment in human capital from health due to increases in mortality rates in most age groups during the Covid-19 crisis.

The estimate of health human capital investment from the income approach is found to be lower than health expenditures. Health human capital investment from income approach as a share of GDP was less than one percent after 1980 while health expenditures as a share of GDP ranged from 7% to 12% in that period. This suggests that much of health expenditures should be classified as consumption rather than investment that contributes to gains in lifetime income.

To have a more comprehensive measure of investment in health human capital, the proposed measurement framework will be used to examine the effect of decline in morbidity on lifetime income of individuals and investment in human capital. For such purpose, health-rated data from Canadian Community Health Survey - Annual Component (CCHS) will be combined with the data developed from LFS and Census in this paper to obtain a full set of matrices of population counts, employment, hours and compensation with a full set of characteristics that include health status of individuals.

Future work should also integrate this health investment component in the national accounts and examine the effect of this integration on macro aggregates such as gross domestic product, investment, income and wealth. This integration will provide better understanding of sources of economic growth.

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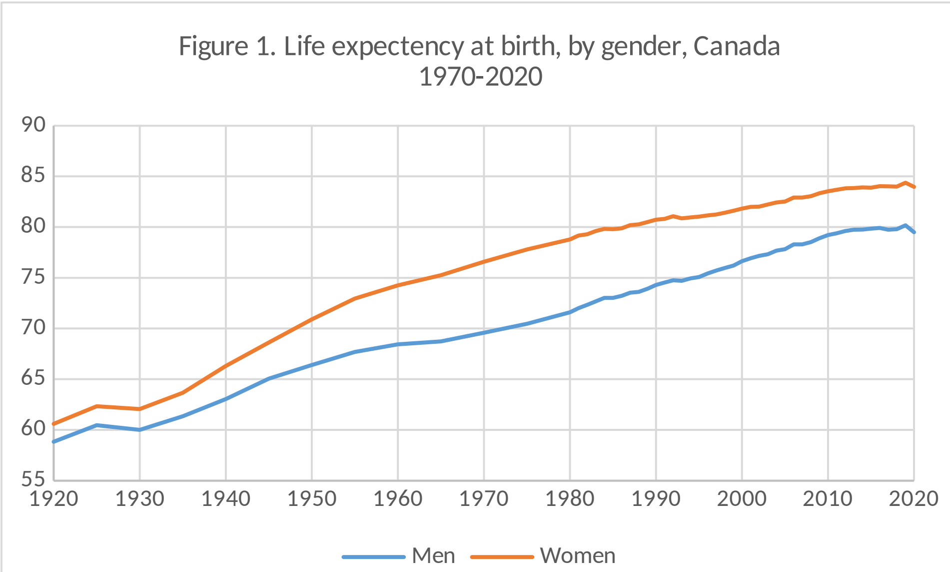
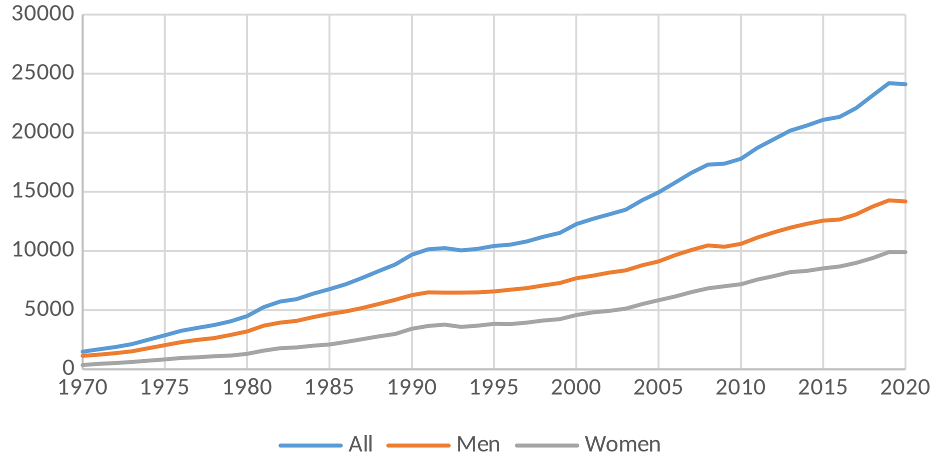


Source, Statistics Canada (2016) and Table 13-10-0114-01.

Figure 2. Human capital stock in billion Canadian dollars, 2012 price, by gender, Canada



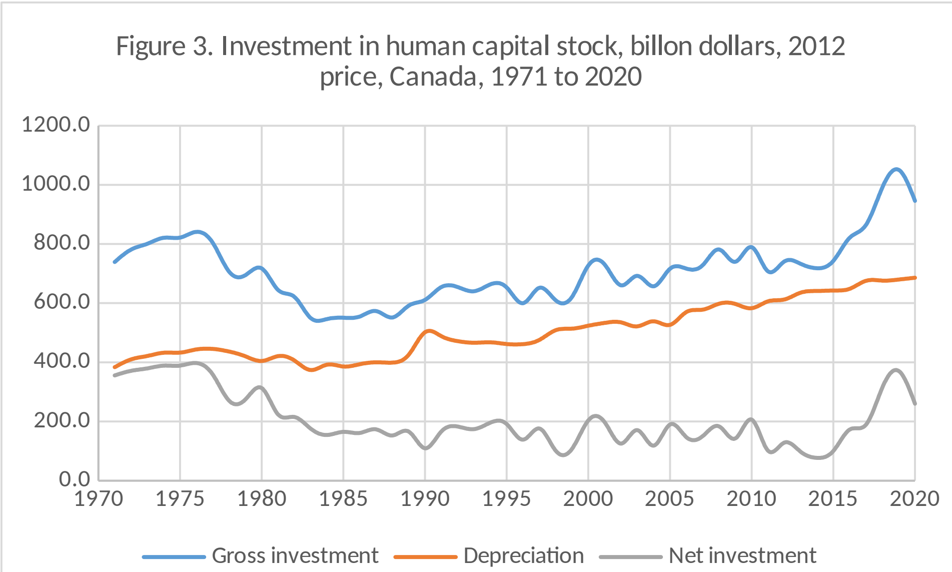


Figure 3. Investment in human capital stock, billon dollars, 2012 price, Canada, 1971 to 2020
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Gross investment
Depreciation
Net investment

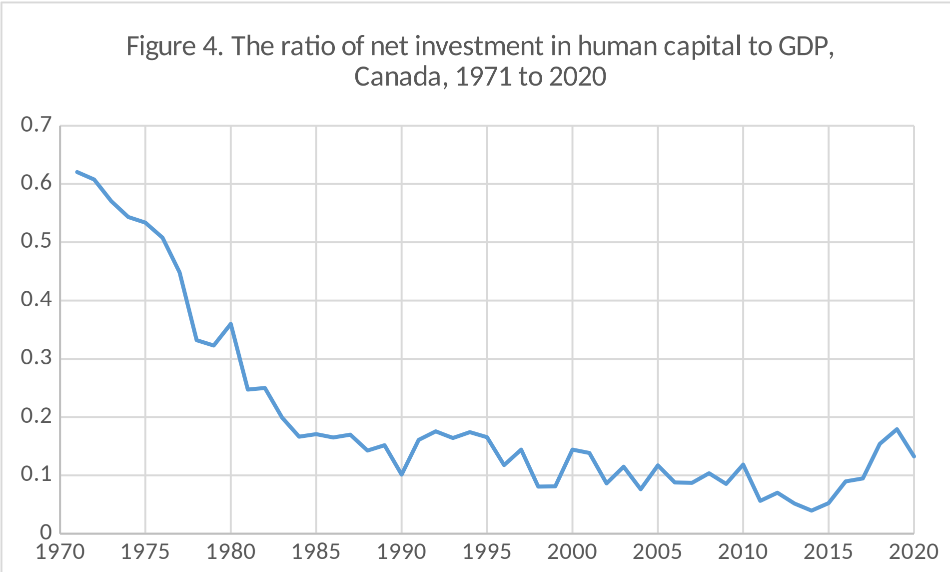


Figure 4. The ratio of net investment in human capital to GDP,
Canada, 1971 to 2020
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020

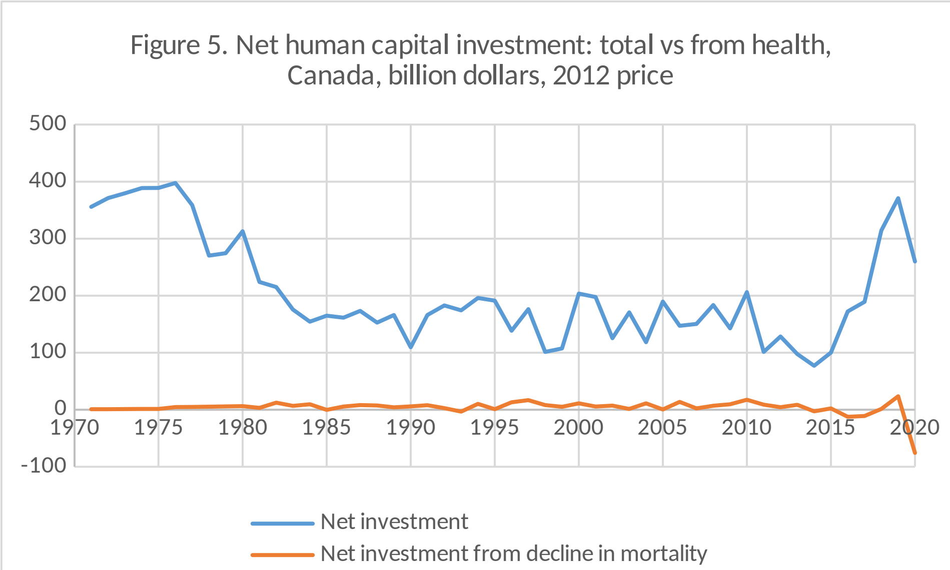
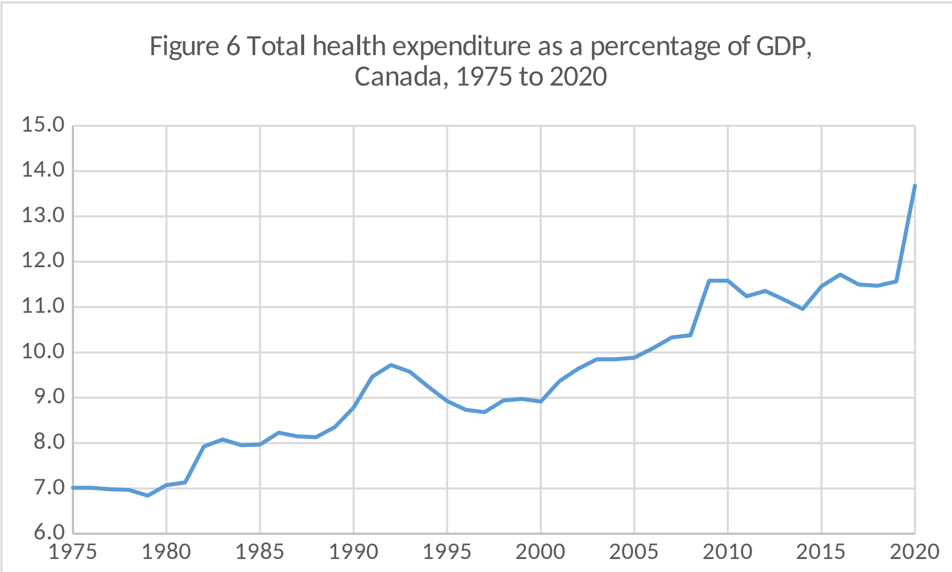


Figure 5. Net human capital investment: total vs from health, Canada, billion dollars, 2012 price
500
400
300
200
100
0
-100
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Net investment
Net investment from decline in mortality



Source, CIHI, 2019

Table 1. Decomposition of changes in human capital stock, billion dollars, 2012 price

	Addition to population	Effect of education and immigration	Effect of aging	Subtraction of population	Revaluation
1971	619	120	363	21	799
1972	637	144	388	22	724
1973	638	163	399	22	909
1974	640	181	409	24	1,331
1975	627	194	409	24	1,134
1976	630	211	418	25	1,118
1977	606	198	420	25	524
1978	585	122	413	24	535
1979	536	158	397	23	705
1980	510	207	382	23	908
1981	483	162	398	23	1,631
1982	431	191	384	22	818
1983	393	157	354	20	248
1984	409	137	371	20	788
1985	416	135	366	20	567
1986	411	144	373	21	612
1987	398	175	379	21	791
1988	393	159	378	21	827
1989	408	184	404	22	740
1990	453	158	480	22	1,165
1991	435	219	467	21	522
1992	425	229	451	21	-36
1993	411	229	446	20	-443
1994	419	244	446	21	-25
1995	422	231	441	20	144
1996	423	177	440	21	25
1997	425	227	455	20	184
1998	443	167	489	20	430
1999	446	175	494	20	312
2000	454	273	503	20	753
2001	471	259	513	20	355
2002	451	209	515	20	343
2003	429	263	501	20	283
2004	449	208	517	22	827
2005	479	237	505	22	557
2006	504	213	547	23	777
2007	495	233	555	23	748
2008	500	281	574	24	563
2009	493	247	574	24	-55

	Addition to population	Effect of education and immigration	Effect of aging	Subtraction of population	Revaluation
2010	479	310	559	24	224
2011	497	211	583	24	836
2012	474	267	588	24	597
2013	472	261	610	25	630
2014	469	249	616	25	336
2015	464	279	617	25	370
2016	461	360	623	25	60
2017	484	381	649	27	503
2018	478	512	648	28	658
2019	499	552	651	29	563
2020	468	477	659	27	-343

Table 2. Investment in human capital per year from decline in mortality rates, Canada, billion dollars, 2012 price

	Gross investment	Depreciation	Net investment	Net investment from decline in mortality	Share of decline in mortality in net investment (%)
1971 to 1980	858.6	470.0	388.6	3.6	0.9
1981 to 1990	643.8	455.3	188.5	7.0	3.7
1991 to 2000	719.5	537.6	181.9	8.1	4.5
2001 to 2010	801.3	620.1	181.2	8.4	4.6
2011 to 2019	921.1	727.2	193.9	2.8	1.4
2020	945.8	685.9	259.9	-75.8	-29.2

Table 3. Investment in human capital per year from decline in mortality rates by gender, Canada, billion dollars, 2012 price

	Gross investment	Depreciation	Net investment	Net investment from decline in mortality	Share of decline in mortality in net investment (%)
Men					
1971 to 1980	538.1	258.7	279.4	3.0	1.1
1981 to 1990	391.3	267.7	123.6	5.6	4.6
1991 to 2000	428.3	322.2	106.1	6.9	6.5
2001 to 2010	463.5	367.6	95.9	6.5	6.8
2011 to 2019	534.4	421.8	112.6	1.6	1.4
2020	533.4	395.1	138.3	-62.6	-45.3
Women					
1971 to 1980	320.4	211.2	109.2	0.6	0.5
1981 to 1990	252.5	187.7	64.9	1.3	2.0
1991 to 2000	291.2	215.4	75.8	1.2	1.6
2001 to 2010	337.8	252.5	85.3	1.8	2.2
2011 to 2019	386.8	305.4	81.4	1.2	1.5
2020	412.4	290.8	121.6	-13.2	-10.9

Table 4. The effect of the decline in mortality rates on human capital stock, by gender, 2019, Canada

	Actual	Based on 1970 mortality rates	Absolute Increase	Percentage Increase
	(1)	(2)	(1)-(2)	((1)-(2))/(1)
Total human capital stock (billion dollars, 2012 price)				
All	24,195	23,421	774	3.2
Men	14,288	13,701	587	4.1
Women	9,907	9,720	187	1.9
Human capital per capita (thousand dollars, 2012 price)				
All	857	830	27	3.2
Men	1015	973	42	4.1
Women	701	688	13	1.9

Table 5. The effect of the increase in mortality rates on human capital stock, by gender, 2020, Canada

	Actual	Based on 2019 mortality rates	Absolute Increase	Percentage Increase
Total human capital stock (billion dollars, 2012 price)				
All	24,101	24,177	-76	-0.3
Men	14,194	14,257	-63	-0.4
Women	9,907	9,920	-13	-0.1
Human capital per capita (thousand dollars, 2012 price)				
All	845	848	-3	-0.3
Men	998	1003	-4	-0.4
Women	693	694	-1	-0.1