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Reductions in life expectancy directly associated with COVID-19 in 2020

by Patrice Dion

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CENTRE FOR DEMOGRAPHY

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REDUCTIONS IN LIFE EXPECTANCY DIRECTLY ASSOCIATED WITH COVID-19 IN 2020

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Introduction

Life expectancy is an indicator widely used to measure the health of populations. It can be defined as the average number of years lived by newborns who would be exposed to the conditions observed in a given period throughout their lives. Even if it is relatively complex to calculate, it can be interpreted intuitively. This indicator also lends itself well to comparisons over time, making it possible to capture changes in peoples' living conditions.

The aim of this study is to measure the reduction in life expectancy at birth (LEB) as a direct consequence of the pandemic in the country and in the affected provinces. To do this, two LEB estimates are produced and compared: one reflecting a hypothetical situation without a pandemic, and the other taking into account deaths attributed to COVID-19 in 2020. The results are evaluated in light of the LEB changes observed in recent years.

Findings

Over 15,000 deaths attributed to COVID-19 in 2020 in the country

According to surveillance data produced by the Public Health Agency of Canada, COVID-19 caused over 15,600 deaths in the country in 2020, for a Crude COVID-19 Death Rate (CCDR) of 0.41 per thousand (Table 1). The average age of Canadians who died of COVID-19 in 2020 is 83.8 years. By comparison, the average age at death in Canada in 2019 was 76.5 years.

Some provinces were hit harder than others. With more than half of the deaths due to COVID-19 in the country in 2020, Quebec has a CCDR of 0.96 per thousand, more than double the Canadian value. Conversely, the CCDR was less than half the Canadian value in Nova Scotia, Saskatchewan and British Columbia. Lastly, fewer than 10 COVID deaths were counted in Newfoundland and Labrador, Prince Edward Island, New Brunswick and the territories.

Table 1
COVID-19 mortality indicators and life expectancy in 2019, Canada and provinces that counted at least 10 deaths due to COVID-19

Region	Deaths, due to COVID-19	Average age at death, due to COVID-19	Crude death rate, due to COVID-19	Life expectancy in 2019
	number	in years	per thousand	in years
Canada	15,651	83.8	0.41	82.10
Nova Scotia	65	81.5	0.07	80.39
Quebec	8,226	84.2	0.96	82.86
Ontario	4,576	83.0	0.31	82.44
Manitoba	667	77.8	0.48	80.07
Saskatchewan	155	71.8	0.13	80.31
Alberta	1,046	82.9	0.24	81.62
British Columbia	901	84.4	0.18	82.36

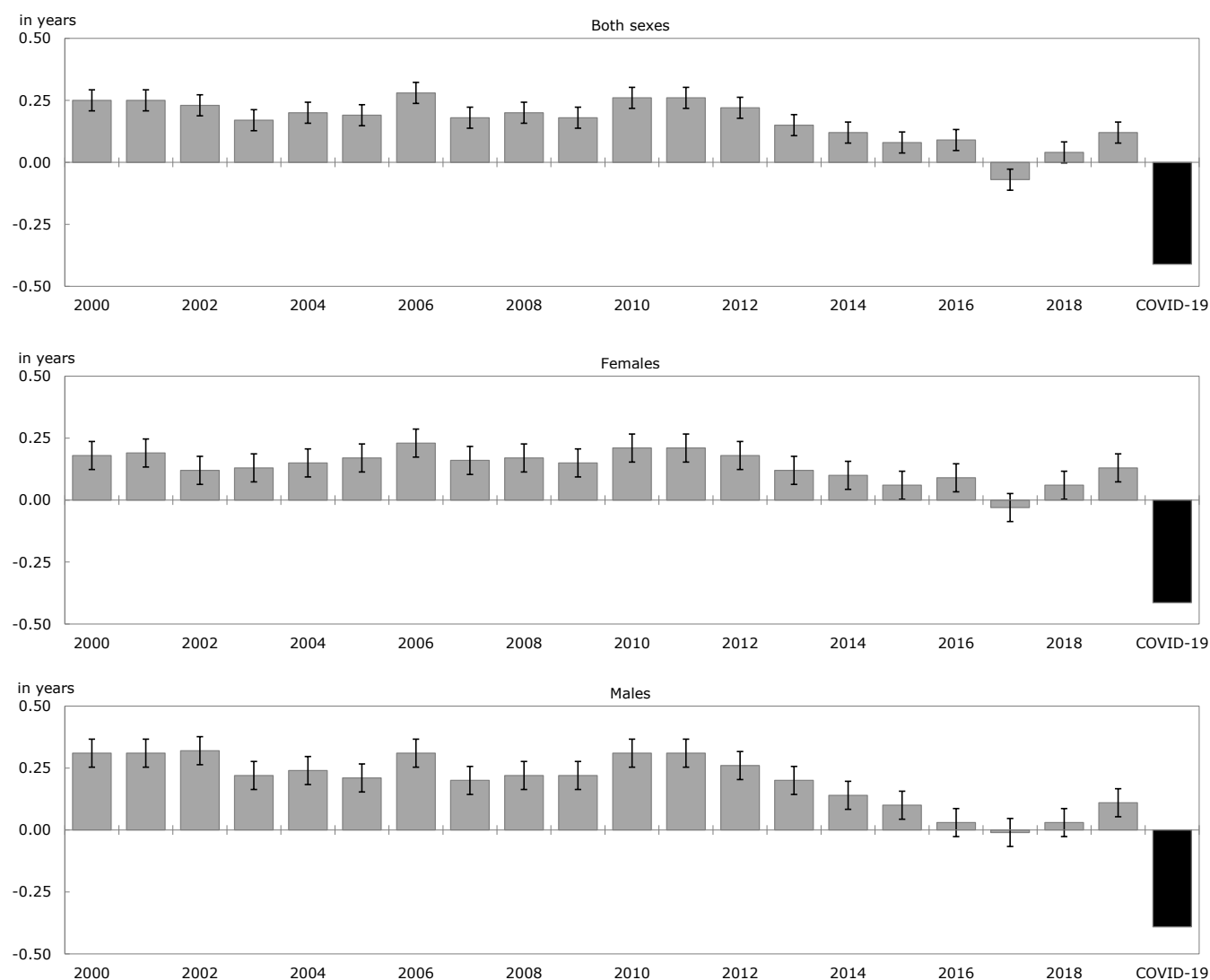
Sources: Public Health Agency of Canada, Coronavirus disease 2019 (COVID-19), Daily Epidemiology Update, updated January 24, 2021. Statistics Canada: Canadian Vital Statistics Database, provisional death counts; Population estimates on July 1, by age and sex, Table 17-10-0005-01; Life expectancy and other elements of the life table, Canada, all provinces except Prince Edward Island, Table 13-10-0114-01.

Deaths caused by COVID-19 contributed to an estimated reduction in LEB of 0.41 years in 2020 in Canada

Life expectancy at birth (LEB) in Canada in 2020 is still unknown, but it will likely be lower compared with previous years. Deaths caused by COVID-19 contributed to an estimated reduction in LEB of 0.41 years in 2020. Compared to the life expectancy of 82.10 years observed in 2019, this decrease of 0.41 years would reduce LEB to what it was six years earlier, in 2013 (81.68 years).

Chart 1 shows the changes in LEB in Canada in the past 20 years and the variation associated with COVID-19. LEB grew almost continuously during this period; in fact, it has done so since 1921.^[1] From 2000 to 2019, gains were slightly larger among men than women. Larger at the start of the period, annual gains were smaller thereafter. LEB even experienced a slight decrease of 0.07 years in 2017, which was caused in large part by the opioid epidemic that was raging in Canada.^[2] In the past decade, LEB has risen by 0.13 years on average. By comparison, the estimated reduction in LEB associated with COVID-19 is three times larger.

Chart 1
Annual variations in life expectancy at birth, 1999 to 2019, and reduction caused by COVID-19 by sex, Canada



Notes: Life expectancy estimates are calculated for three-year periods. The year indicated represents the last year of the period. The confidence intervals reflect the expected impact of random fluctuations over time on the estimated annual variations in LEB. When the interval excludes zero, the probability of the annual variation being the result of pure chance alone is low (< 5%).

Source: Statistics Canada, Centre for Demography.

Provinces and territories affected unevenly

Table 2 presents the annual variations in LEB in Canada over the past 10 years as well as the variation associated with COVID-19 by sex for Canada and selected provinces. With fewer than 10 deaths due to COVID-19 in Newfoundland and Labrador, Prince Edward Island, New Brunswick and the territories, the estimated impact on LEB is marginal.

Quebec is where the impact of COVID-19 on LEB was most significant, totalling 0.84 years, or twice the estimated value for Canada. Manitoba, Ontario and Alberta follow with estimated reductions of 0.60, 0.34 and 0.32 years, respectively. In these provinces, the reduced LEB caused by COVID-19 represents a relatively significant change in comparison with past annual variations. In British Columbia, the estimated reduction in LEB is of a similar magnitude to LEB reduction observed between 2016 and 2017, which was mostly due to an increase in deaths related to opioid overdoses.

In Manitoba and Saskatchewan, the estimated reduction in LEB due to COVID-19 is higher among males than females. Elsewhere, the gaps are too small to conclude that there are different impacts by sex.

Table 2
Annual variations in life expectancy at birth, 2010 to 2019, and reduction caused by COVID-19 by sex, Canada and provinces that counted at least 10 deaths due to COVID-19

Region	Sex	Indicator	Year										COVID-19
			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
Canada	Both sexes	Variation	0.26	0.26	0.22	0.15	0.12	0.08	0.09	-0.07	0.04	0.12	-0.41
		C.I.	0.22 to 0.30	0.22 to 0.30	0.18 to 0.26	0.11 to 0.19	0.08 to 0.16	0.04 to 0.12	0.05 to 0.13	-0.11 to -0.03	0.00 to 0.08	0.08 to 0.16	
	Females	Variation	0.21	0.21	0.18	0.12	0.10	0.06	0.09	-0.03	0.06	0.13	-0.41
		C.I.	0.15 to 0.27	0.15 to 0.27	0.12 to 0.24	0.06 to 0.18	0.04 to 0.16	0.00 to 0.12	0.03 to 0.15	-0.09 to 0.03	0.00 to 0.12	0.07 to 0.19	
	Males	Variation	0.31	0.31	0.26	0.20	0.14	0.10	0.03	-0.01	0.03	0.11	-0.39
		C.I.	0.25 to 0.37	0.25 to 0.37	0.20 to 0.32	0.14 to 0.26	0.08 to 0.20	0.04 to 0.16	-0.03 to 0.09	-0.07 to 0.05	-0.03 to 0.09	0.05 to 0.17	
Nova Scotia	Both sexes	Variation	0.25	0.10	0.13	0.04	0.10	-0.13	0.07	-0.02	0.06	-0.08	-0.05
		C.I.	0.02 to 0.48	-0.13 to 0.33	-0.10 to 0.36	-0.19 to 0.27	-0.13 to 0.33	-0.36 to 0.10	-0.16 to 0.30	-0.25 to 0.21	-0.17 to 0.29	-0.31 to 0.15	
	Females	Variation	0.29	0.07	0.01	0.04	0.18	-0.16	0.12	-0.13	0.08	-0.19	-0.07
		C.I.	-0.04 to 0.62	-0.26 to 0.40	-0.32 to 0.34	-0.29 to 0.37	-0.15 to 0.51	-0.49 to 0.17	-0.21 to 0.45	-0.46 to 0.20	-0.25 to 0.41	-0.51 to 0.13	
	Males	Variation	0.23	0.13	0.23	0.05	0.11	-0.11	0.05	0.01	0.04	0.07	-0.05
		C.I.	-0.08 to 0.54	-0.18 to 0.44	-0.08 to 0.54	-0.26 to 0.36	-0.20 to 0.42	-0.42 to 0.20	-0.26 to 0.36	-0.30 to 0.32	-0.27 to 0.35	-0.24 to 0.38	
Quebec	Both sexes	Variation	0.25	0.25	0.18	0.18	0.14	0.10	0.20	0.14	0.25	0.22	-0.84
		C.I.	0.17 to 0.33	0.17 to 0.33	0.10 to 0.26	0.10 to 0.26	0.06 to 0.22	0.03 to 0.17	0.13 to 0.27	0.07 to 0.21	0.18 to 0.32	0.15 to 0.29	
	Females	Variation	0.18	0.19	0.14	0.11	0.08	0.08	0.14	0.12	0.14	0.22	-0.84
		C.I.	0.07 to 0.29	0.08 to 0.30	0.03 to 0.25	0.00 to 0.22	-0.03 to 0.19	-0.03 to 0.19	0.03 to 0.25	0.01 to 0.23	0.03 to 0.25	0.12 to 0.32	
	Males	Variation	0.32	0.31	0.22	0.26	0.21	0.15	0.26	0.16	0.37	0.23	-0.80
		C.I.	0.21 to 0.43	0.20 to 0.42	0.11 to 0.33	0.15 to 0.37	0.10 to 0.32	0.04 to 0.26	0.16 to 0.36	0.06 to 0.26	0.27 to 0.47	0.13 to 0.33	
Ontario	Both sexes	Variation	0.25	0.27	0.25	0.19	0.10	0.08	0.05	-0.01	-0.03	0.06	-0.34
		C.I.	0.19 to 0.31	0.21 to 0.33	0.19 to 0.31	0.13 to 0.25	0.04 to 0.16	0.02 to 0.14	-0.01 to 0.11	-0.07 to 0.05	-0.09 to 0.03	0.00 to 0.12	
	Females	Variation	0.21	0.24	0.20	0.18	0.09	0.04	0.04	0.01	0.02	0.10	-0.32
		C.I.	0.13 to 0.29	0.16 to 0.32	0.12 to 0.28	0.10 to 0.26	0.01 to 0.17	-0.04 to 0.12	-0.04 to 0.12	-0.07 to 0.09	-0.06 to 0.10	0.02 to 0.18	
	Males	Variation	0.30	0.31	0.29	0.20	0.12	0.12	0.07	-0.02	-0.06	0.03	-0.33
		C.I.	0.22 to 0.38	0.23 to 0.39	0.21 to 0.37	0.12 to 0.28	0.04 to 0.20	0.05 to 0.21	-0.01 to 0.15	-0.10 to 0.06	-0.14 to 0.02	-0.05 to 0.11	
Manitoba	Both sexes	Variation	0.26	0.16	0.20	0.13	0.03	0.00	-0.11	0.00	0.01	0.07	-0.60
		C.I.	0.04 to 0.48	-0.05 to 0.37	-0.01 to 0.41	-0.08 to 0.34	-0.18 to 0.24	-0.21 to 0.21	-0.32 to 0.10	-0.21 to 0.21	-0.20 to 0.22	-0.14 to 0.28	
	Females	Variation	0.15	0.06	0.16	0.21	0.05	-0.06	-0.15	-0.06	0.08	0.08	-0.49
		C.I.	-0.16 to 0.46	-0.25 to 0.37	-0.15 to 0.47	-0.10 to 0.52	-0.25 to 0.35	-0.36 to 0.24	-0.45 to 0.15	-0.36 to 0.24	-0.22 to 0.38	-0.22 to 0.38	
	Males	Variation	0.40	0.25	0.23	0.08	0.02	0.06	-0.06	0.03	-0.02	0.06	-0.66
		C.I.	0.10 to 0.70	-0.05 to 0.55	-0.07 to 0.53	-0.22 to 0.38	-0.28 to 0.32	-0.24 to 0.36	-0.36 to 0.24	-0.27 to 0.33	-0.32 to 0.28	-0.24 to 0.36	
Saskatchewan	Both sexes	Variation	0.03	0.17	0.20	0.15	0.12	-0.03	0.08	0.07	0.03	0.06	-0.18
		C.I.	-0.21 to 0.27	-0.07 to 0.41	-0.04 to 0.44	-0.09 to 0.39	-0.11 to 0.35	-0.26 to 0.20	-0.15 to 0.31	-0.16 to 0.30	-0.20 to 0.26	-0.17 to 0.29	
	Females	Variation	0.06	0.05	0.14	0.10	0.11	-0.01	0.13	0.08	-0.02	0.08	-0.04
		C.I.	-0.28 to 0.40	-0.29 to 0.39	-0.19 to 0.47	-0.23 to 0.43	-0.22 to 0.44	-0.34 to 0.32	-0.20 to 0.46	-0.25 to 0.41	-0.35 to 0.31	-0.25 to 0.41	
	Males	Variation	-0.02	0.25	0.29	0.20	0.15	-0.06	0.07	0.07	0.10	0.03	-0.29
		C.I.	-0.35 to 0.31	-0.08 to 0.58	-0.04 to 0.62	-0.13 to 0.53	-0.18 to 0.48	-0.38 to 0.26	-0.24 to 0.38	-0.24 to 0.38	-0.22 to 0.42	-0.30 to 0.36	
Alberta	Both sexes	Variation	0.27	0.36	0.20	0.04	0.01	0.01	0.05	-0.02	0.03	0.17	-0.32
		C.I.	0.14 to 0.40	0.23 to 0.49	0.07 to 0.33	-0.09 to 0.17	-0.12 to 0.14	-0.12 to 0.14	-0.08 to 0.18	-0.15 to 0.11	-0.10 to 0.16	0.05 to 0.29	
	Females	Variation	0.28	0.31	0.19	-0.03	-0.04	0.03	0.12	0.09	0.09	0.14	-0.29
		C.I.	0.10 to 0.46	0.13 to 0.49	0.01 to 0.37	-0.21 to 0.15	-0.21 to 0.13	-0.14 to 0.20	-0.05 to 0.29	-0.08 to 0.26	-0.08 to 0.26	-0.03 to 0.31	
	Males	Variation	0.27	0.41	0.21	0.12	0.06	-0.01	0.00	-0.10	-0.02	0.20	-0.33
		C.I.	0.09 to 0.45	0.23 to 0.59	0.03 to 0.39	-0.05 to 0.29	-0.11 to 0.23	-0.18 to 0.16	-0.17 to 0.17	-0.27 to 0.07	-0.19 to 0.15	0.03 to 0.37	
British Columbia	Both sexes	Variation	0.34	0.38	0.26	0.14	0.12	0.02	-0.07	-0.20	-0.13	0.15	-0.17
		C.I.	0.23 to 0.45	0.27 to 0.49	0.15 to 0.37	0.03 to 0.25	0.01 to 0.23	-0.08 to 0.12	-0.17 to 0.03	-0.30 to -0.10	-0.23 to -0.03	0.05 to 0.25	
	Females	Variation	0.25	0.37	0.25	0.17	0.15	0.03	-0.03	-0.07	0.04	0.16	-0.17
		C.I.	0.09 to 0.41	0.21 to 0.53	0.09 to 0.41	0.01 to 0.33	-0.01 to 0.31	-0.13 to 0.19	-0.18 to 0.12	-0.21 to 0.07	-0.11 to 0.19	0.00 to 0.32	
	Males	Variation	0.42	0.39	0.27	0.14	0.09	0.00	-0.12	-0.30	-0.26	0.15	-0.18
		C.I.	0.28 to 0.56	0.25 to 0.53	0.13 to 0.41	0.00 to 0.28	-0.05 to 0.23	-0.14 to 0.14	-0.26 to 0.02	-0.44 to -0.16	-0.40 to -0.12	0.01 to 0.29	

Notes: Life expectancy estimates are calculated for three-year periods. The year indicated represents the last year of the period. The confidence intervals reflect the expected impact of random fluctuations over time on the estimated annual variations in LEB. When the interval excludes zero, the probability of the annual variation being the result of pure chance alone is low (< 5%).

Source: Statistics Canada, Centre for Demography.

Discussion

At the time of writing, the COVID-19 pandemic had claimed over 20,000 lives in the country.^[3] By comparison, 17,600 deaths were attributed to a lethal overdose of opioids between January 2016 and June 2020.^[4] Similarly, about 18,300 people died of HIV at the height of the epidemic in Canada (between 1987 and 2011).^[5]

Despite these similarities in the number of victims, the opioid crisis and the HIV epidemic have very different effects from COVID-19 in many ways. First, they generally affect younger populations, particularly young adults. For example, over a quarter (27%) of the people who died of an opioid overdose in 2017 were between the ages of 30 and 39 at the time of their death. By comparison, only 0.15% of deaths caused by COVID-19 in 2020 (and 1.6% of deaths from all causes in 2019) occurred in this age group. Also, compared with the opioid crisis and the HIV epidemic, the deaths caused by COVID-19 occurred over a much shorter period. Lastly, in addition to the actual deaths, the opioid crisis, the HIV epidemic, and COVID-19 probably differ in the intensity of the care required to treat the people affected and the impact and costs of preventive measures.

Few studies have estimated the impact of the HIV and opioid epidemics on LEB in Canada. One study estimated a reduction in LEB due to opioid overdose deaths of 0.11 years for men and 0.02 years for women in Canada in 2017,^[2] well below the estimated reduction in LEB for men (0.39 years) and for women (0.41 years) associated with the COVID-19 pandemic in 2020. In British Columbia, however, where the opioid epidemic hit harder, the reduction in LEB in 2017 was 0.28 years among men, exceeding the reduction of 0.18 years caused by COVID-19 deaths in 2020. That said, these single-year comparisons are imperfect, as the opioid epidemic spanned multiple years, making it longer duration than the COVID-19 pandemic as of now.

One advantage of the reduction in LEB as an indicator is that it is sensitive to age at death, and therefore to the number of years of life lost by the people who died. However, by itself, it is a poor measure of the extent of a health crisis, in particular because it is not overly affected by changes that occur at advanced ages,^[6] and because it poorly conveys the abrupt changes in the number of deaths that can still cause major problems in the delivery of health care services and for public health institutions in general.^[7] In this sense, the reduction in LEB is an indicator that complements others, such as fluctuations in the number of daily deaths due to COVID-19 or weekly excess mortality.

While it is difficult to compare the impact of COVID-19 with that of previous epidemics, how does it compare to the situation elsewhere in the world? In the United States, Andrasfay and Goldman^[8] estimated the direct effect of COVID-19 on LEB at 1.26 years, triple the value of 0.41 years estimated in Canada. In another study covering close to 200 countries, Heuveline and Tzen^[9] estimated a direct effect of COVID-19 on life expectancy in Canada at 0.55 years. The discrepancy of 0.14 years with the proposed estimate here is mostly due to differences in the assumptions on the distribution of deaths by age and the timeliness of the data used. Despite these discrepancies, the results of this study compare the situation of Canada with other countries, showing that the reduction in LEB in Canada is less than that experienced in many European countries such as Italy, Spain, France, Sweden, the Netherlands and Austria, but higher than in other countries such as Germany, Denmark, Finland, Norway, Australia and New Zealand.

Clearly, the reduction in LEB caused directly by COVID-19 gives only a partial picture of the overall effect of the pandemic in the country. It must be interpreted strictly as a measure of the estimated impact on additional mortality caused directly by COVID-19, and therefore would not represent the actual change in life expectancy between 2019 and 2020. Other factors could also have an indirect but significant impact on the health of Canadians, such as delayed medical care due to changes in priorities in the delivery of health care, repercussions associated with physical distancing measures, or the impact of the economic slowdown. Some changes may have a positive impact, such as fewer deaths due to reduced automobile traffic. Indirect impacts are likely to affect not only the number of deaths, but also the age at death, which could have an impact on life expectancy estimates. Excess mortality observed in younger populations in the last months of 2020 suggests a possible increase in deaths attributable to other causes.^[10]

In Canada, it will be possible to estimate life expectancy observed in 2020 once death data have reached an acceptable level of completeness. These estimates will then provide a portrait of the overall effect, or the sum of the direct and indirect effects, of COVID-19. That said, the indirect impacts of the measures adopted in 2020 to fight the pandemic may emerge later in the coming years.

Elsewhere in the world and in the province of Quebec, preliminary estimates show a decrease in life expectancy observed in 2020 compared with the previous year. For example, in France, life expectancy decreased by 0.5 years among males and 0.4 years among females.^[11] In the Netherlands, the decrease was 0.8 years among males and 0.5 years among females.^[12] In the United States, estimates for the first half of the year show a decrease of 1.2 years among males and 0.9 years among females.^[13] Lastly, the Institut de la statistique du Québec published preliminary estimates of LEB in 2020 that showed decreases of 0.4 years among males and 0.7 years among females.^[14] These estimates for Quebec are lower than those estimated in this study, especially among males. These gaps may be the result of indirect effects, such as lower mortality associated with other causes. Analyses of the number of deaths by cause may provide a better understanding of the contributions of the direct and indirect effects of the pandemic.

Methods

Estimated reduction in life expectancy due to COVID-19

Two essential elements are required to estimate life expectancy: death counts and populations at risk by age or age group. However, to assess the direct impact of the COVID-19 pandemic on life expectancy, the situation observed in 2020 must be compared with a hypothetical non-pandemic situation. This raises two major challenges.

The first challenge involves obtaining data for the year 2020 soon after the end of the year. The death counts by age and sex associated with COVID-19 are taken from the Canadian Vital Statistics Death Database (CVSD). In total, 13,629 records of deaths from COVID-19 that occurred in the country in 2020 were extracted from the CVSD.^[15] However, due to delays in registering deaths and especially in attributing causes of death, this is quite likely underestimated. To rectify this, the death counts by age and sex from the CVSD were inflated to correspond to the total number of deaths from surveillance data produced by provincial and territorial public health authorities and collected by the Public Health Agency of Canada (PHAC). According to these data, which are less detailed but more current, 15,651 deaths due to COVID-19 occurred in Canada in 2020.^[3]

It should be noted that the estimates of the total number of deaths due to COVID-19 from PHAC surveillance data may vary from the official estimates produced using the CVSD for a given period. The dates associated with the deaths in the PHAC data do not always reflect the date of death; they sometimes reflect the date on which the death was registered. In addition, data from the PHAC reflect confirmed cases of infection with COVID-19 and may therefore exclude the deaths of individuals who were not tested. That said, despite the conceptual limitations related to the measure of deaths, the excess mortality estimates are quite comparable to the number of deaths due to COVID-19.^[46]

The second challenge associated with measuring the direct effect of the COVID-19 pandemic on life expectancy is producing an estimate based on a hypothetical situation that could serve as a basis for comparison with the year 2020. To do this, the deaths that would hypothetically have occurred in 2020 in the absence of COVID-19 are first produced by applying the mortality rates from the most recent Statistics Canada mortality tables, which cover the period from 2017 to 2019,^[17] to the 2020 population,^[18] adjusted to remove the impact of the pandemic. Modified versions of the 2017 to 2019 tables that reflect the additional mortality caused by COVID-19 are then produced by adjusting certain elements of the table based on the ratio of "non-COVID" deaths to total deaths (including "non-COVID" deaths and previously estimated COVID deaths). This method, proposed by Chiang,^[19] presumes here that the effects of COVID-19 over an age interval are proportional to those of other causes of death. The impact of COVID-19 on life expectancy is calculated simply by comparing the estimates produced in both mortality tables, with and without COVID-19. The method is described in Preston et al.^[20] in the context of estimating the impact of a given cause of mortality on the conditions observed. See also Andrasfay and Goldman^[8] for an application similar to this study in the United States, and Heuveline and Tzen^[9] for a study covering several countries and regions around the world.

Calculating the confidence intervals of the estimated variation in LEB

In Statistics Canada's mortality tables, the margins of error associated with the life expectancy estimates reflect the expected variations over time given that mortality is a random process (natural variability), based on the assumption that deaths follow a binomial distribution.^[21] ¹ The 95% confidence intervals associated with annual variations in LEB were computed by adding the variances associated with consecutive estimates of LEB.² According to this approach, these variances are independent, which is counterintuitive given that LEB values are three-year averages, but proves to be adequate given their strict definition.

1. See C.L. Chiang (1968) (reference [19]) for details of the variance calculation associated with the life expectancy estimates in the mortality tables.

2. The exact formula is: $m.e. = 1.96 \bullet \sqrt{Var(e_0^{t-1}) + Var(e_0^t)}$.

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