

Research report

C-19 Canadian Mortality Model Report

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Introduction

The C-19 Canadian Mortality Model was developed in Excel after a request for papers (RFP) was put out by the Research Council of the Canadian Institute of Actuaries (CIA) in the spring of 2020. The RFP requested research related to COVID-19 and its actuarial implications. This report documents a model developed in response to the RFP.

The C-19 Canadian Mortality Model was developed to assist actuaries modelling extra deaths as a result of the COVID-19 pandemic. It is Excel-based and intended to be user-friendly. This report acts as a manual of how to use the model, which is available on the Seeing Beyond Risk website within the [COVID-19 section](https://www.seeingbeyonddrisk.ca/tag/covid-19/) link <https://www.seeingbeyonddrisk.ca/tag/covid-19/>.

The author of this report is Terry Narine, FCIA, FSA. The author would like to thank the members of the project oversight group who reviewed the model and research report and provided guidance along the way:

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Model layout

Within the Excel model are nine worksheets. These are Exec Sum, Instructions, Extra Mortality, Raw Data, Fatality Rate, Live Data, Pop'n, World Data and Links. There are three sections below on the flow of the model. These involve the instruction tabs, calculation tab and data tabs. Each sheet within these three sections will be individually discussed below.

Instruction tabs

The instruction tabs are the Exec Sum (“Executive Summary”) and Instructions tabs.

Exec Sum

Exec Sum provides an executive summary of the model. It gives brief insight into the functioning of the other sheets in the model. It highlights that the tool is designed to capture ultimate extra deaths as a result of COVID-19. Since this is an ongoing pandemic, the full extent of its impact and the factual data to be ultimately derived from it are still a work in progress. Care must be taken in using the model and setting assumptions within it.

The model provides an estimate of extra deaths for Canada, the provinces, territories and the cities of Montreal, Toronto, and Vancouver (known hotspots for the virus). These places will collectively be referred to as the “regions”. Extra insured deaths are provided per 100,000 lives of the relevant age and sex and in total by age for the chosen region. The user only has to select the region, the ultimate population fatality rate, and the insured-to-population-mortality factor (more on this in the next section).

One important concept to keep in mind is that extra deaths as produced by the model differ from a mortality rate. Mortality rates apply over a period of time – typically a year. Extra deaths in this model refer to the total expected deaths over the duration of the pandemic as a result of the virus. Care should be taken in converting these extra deaths to an annual mortality rate.

Instructions

The Instructions tab provides direction on user input on the next sheet, called Extra Mortality. See the next section for further details on the user input cells of the model. This tab also includes a disclaimer. The disclaimer asks users to exercise caution in using the model, as the full effects of the pandemic are still being developed. The model uses currently available information, which may change as the effects of the virus develop. The old adage that all models are wrong and models are only as good as their assumptions applies.

Calculation tab

The calculation tab is called Extra Mortality and is the only sheet the user needs to access unless there is a need to update data.

Extra Mortality

The Extra Mortality tab is the key user sheet. Cells C5 to C8, highlighted in yellow, are the main input areas in the model:

Table 1

<u>Input Section</u>	
Input	
Province, Territory or City	Québec
Final Total Pop’n Fatality Rate	0.50000%
Female Insured to Pop’n Adjustment	40.0%
Male Insured to Pop’n Adjustment	40.0%

Cell C5 provides a drop-down menu for the regions or Canada in total. The user would select the region for which they are requesting crude deaths as a result of COVID-19. Cell C6 gives the user an opportunity to select the ultimate total fatality rate of the population being modelled relative to those with the viral infection. A warning will pop-up if the user inputs a fatality rate that is less than the current historic fatality rate for the region.

Cells C7 and C8 allow input of the ratio of expected insured to population deaths for males and females. While this information is still being developed, there is some evidence that this ratio is trending at about 40%. Users are free to choose their own assumptions in this regard.

To the right of the input cells is a section with relevant statistics for the population chosen from the drop-down menu (see Table 2).

The information includes deaths, fatality rates, infections, population, and infection and death rates for the province or territory. It also includes the latest updated deaths and infections for Canada. This information is being read from the Fatality Rate and Pop'n sheets. It is important to keep in mind that the information shown in the model is as of the last time the model was updated and may not reflect the current environment.

Table 2

Statistics	
Regional Deaths	7,056
Regional Fatality Rate	4.96%
Regional Infections	142,371
Population Sep 2020	8,574,571
Regional Infection Rate	1.6604%
Canada Fatality Rate	3.1835%
Canada Deaths	12,146
Canada Infections	381,531

To the right of that section, starting in cell K1, is a section on worldwide statistics:

Table 3

International	
Country	World
Fatality Rate	2.18%
Infections	83,963,772
COVID Deaths	1,827,540
Population	7,713,468,100

The user can choose the country (highlighted in yellow above) to get the latest updated fatality rates and infections, or click on "World" for global figures. A more detailed worldwide model is available in the Blog section of Seeing Beyond Risk.

Below the statistical section is a section calculating crude extra deaths by age:

Table 4

Age	C-19 Projected Crude Deaths	C-19 Crude Fatality Rate by Age Distribution
67	126	0.02575%
68	125	0.02575%
69	124	0.02575%
70	461	0.11598%
...		

The left-hand column shows age. The right-hand column shows fatality rates by population for the corresponding ages. The fatality rates by age are being read from the Raw Data page. The centre column shows crude virus deaths by age for the chosen region. The crude deaths by age take the fatality rate by age and multiply it by the relevant population (male and female) by age of the chosen region. The

population data are obtained from the Pop'n sheet. It then adjusts that result by the ratio of the regional fatality rate to the Canadian fatality rate in order to obtain an appropriate fatality rate for the region. The need to alter fatality rates by region is so the relative extra deaths are reflective of the situation in any given province or territory. Some provinces and territories are experiencing better outcomes than others as a result of “bubbles” and other governmental containment measures.

To the left of the crude deaths section is a table showing crude deaths in total and by male and female breakdowns per 100,000 lives:

Table 5

Age	Female Proportion of C-19 Crude Insured Deaths per 100,000 Lives	Male Proportion of C-19 Crude Insured Deaths per 100,000 Lives	Total C-19 Estimated Crude Insured Deaths per 100,000 Lives
69	16	18	17
70	74	83	78
71	74	83	78
72	74	83	78
			...

Data tabs

The data tabs are Raw Data, Fatality Rate, Live Data, Pop'n (“Population”), World Data and Links. Users would typically update the Pop'n tab if it was necessary to have the latest available information.

Raw Data

The Raw Data tab shows infection rates and fatality rates by age and sex. It also provides graphs of infection and fatality rates by age. There is no need for the user to modify any part of this sheet, as it reads in data from other sheets.

Fatality Rate

The Fatality Rate sheet shows the latest downloaded infections, deaths and fatality rates (deaths divided by infections) for each of the regions and Canada in total. The user does not have to modify information on this sheet, as it accesses data from the Live Data sheet.

Live Data

The Live Data sheet is similar to the Fatality Rate sheet in that it provides infections and deaths by regions and for Canada in total. Users can feel free to update this information periodically from the Stats Canada website as the pandemic progresses. One difference between this sheet and the Fatality Rate sheet is that this worksheet provides a fatality rate that reflects the percentage of COVID-19 deaths in the population rather than as a percentage of infections.

Pop'n

The Pop'n sheet provides much of the key data used in the Extra Mortality sheet. On the left of the worksheet is a tally from Stats Canada on the distribution of the Canadian population by age in total and by sex. These data were derived from the 2016 Census:

Table 6

From Stats Canada 2016 Census*

Canadian Population			
Age	Female	Male	Total
0	180,650	189,085	369,735
1	181,710	190,900	372,610
2	184,945	193,940	378,885
3	187,590	198,615	386,205
4	190,865	200,500	391,365
			...

To the right of that table is a breakdown of the total population by province:

Table 7

Population: Provinces/Territories/Cities	Population Estimate from Stats Canada as of Sept 1, 2020
Canada	38,005,238
Newfoundland	522,103
Prince Edward Island	159,625
New Brunswick	781,476
Nova Scotia	979,351
Québec	8,574,571
Ontario	14,734,014
Manitoba	1,379,263
Saskatchewan	1,178,681
Alberta	4,421,876
British Columbia	5,147,712
Nunavut	39,353
Yukon	42,052
Northwest Territories	45,161
Montréal	4,304,832
Toronto	6,494,674
Vancouver	2,728,191

One item of note is that the Stats Canada census was conducted as of 2016. The data above show population data as of September 2020. An adjustment or gross-up was made in the relevant table (see Table 8 below) to account for the change in the population since 2016.

To the right of the September 2020 population data is a column showing a balancing regional factor.

Table 8

Population: Provinces/Territories/Cities		Balancing Prov Factor to Tie to Current Experience
Canada		100.0%
Newfoundland		4.5%
Prince Edward Island		1.0%
New Brunswick		5.2%
Nova Scotia		8.0%
Québec		141.8%
Ontario		83.3%
Manitoba		114.9%
Saskatchewan		89.3%
Alberta		204.1%
British Columbia		60.6%
Nunavut		1.0%
Yukon		17.9%
Northwest Territories		1.0%
Montréal		44.4%
Toronto		153.8%
Vancouver		116.3%

These factors are derived from a regression of the current model to actuality. In other words, in the Extra Mortality tab, if the Final Total Pop'n Fatality rate in Cell C6 is set to the current regional fatality rate in Cell I3, then the sum of all extra deaths in column H will equal approximately the total COVID-19 deaths shown in Cell I6. The two exceptions are Prince Edward Island and Nunavut. Since neither region has experienced a single COVID-19 death as of the time of this writing, a factor of 1% was applied relative to Canadian deaths to at least add some level of conservatism.

The factors above are then applied in Column H of the Extra Mortality sheet to determine the extra deaths by region. The above methodology is a regression test in a way suggesting that the model as currently constructed is predicting today's situation with significant accuracy.

On the Pop'n sheet, cells T5 to BS106 show the breakdown of the regional populations by age:

Table 9

Age	Canada	Newfoundland	Prince Edward Island	New Brunswick	Nova Scotia	...
0	369,735	5,079	1,553	7,603	9,528	...
1	372,610	5,119	1,565	7,662	9,602	...
2	378,885	5,205	1,591	7,791	9,763	...
3	386,205	5,306	1,622	7,941	9,952	...
4	391,365	5,376	1,644	8,047	10,085	...
...						

Again, one item of note is that the Stats Canada census was conducted as of 2016. The data above show population data as of September 2020. An adjustment or gross-up was made in the table to account for the change in the population, per Table 7. The adjustment to the population data was done in order to obtain a more precise fatality rate for the various regions.

To the right of that information is the Canadian fatality rates by age grouping (cells CJ6 to CV16; see Table 10). It is these data that are incorporated into the Extra Mortality sheet of fatality rates by age distribution. This is Stats Canada-derived data.

Table 10

From Stats Canada May 4, 2021

Age Range	Range	Fatality	Male %	Female %	Population	...	Fat Rate	Male Fat	Female Fat
0-19	0	2	51%	49%	7,865,730	...	0.0000003	0.0000001	0.0000001
20-29	20	13	49.90%	50.10%	4,528,690	...	0.0000029	0.0000014	0.0000014
30-39	30	23	48.90%	51.10%	4,617,765	...	0.0000050	0.0000024	0.0000025
40-49	40	70	46.60%	53.40%	4,615,105	...	0.0000152	0.0000071	0.0000081
50-59	50	283	47.80%	52.20%	5,298,305	...	0.0000534	0.0000255	0.0000279
60-69	60	848	51.60%	48.40%	4,262,990	...	0.0001989	0.0001026	0.0000963
70-79	70	2148	49.70%	50.30%	2,442,725	...	0.0008793	0.0004370	0.0004423
80+	<u>80</u>	<u>8235</u>	33.30%	66.70%	1,520,425	...	0.0054162	0.0018036	0.0036126
Total		11622			35,151,735				

Just below that section is a table showing fatality rates by age grouping from the Centers for Disease Control (CDC). This section is included only for comparison purposes with US statistics and is not used in the model.

Table 11

From the CDC Oct 23, 2020

Age	Cases	Fatality	Age	Population	...	Inf Rate
0-4	106,356	35	0-4	19,736,000	...	0.00538893
5-17	452,918	66	5-17	53,281,296	...	0.00850051
18-29	1,519,919	855	18-29	53,137,704	...	0.0286034
30-39	1,055,659	2,135	30-39	43,375,000	...	0.02433796
40-49	969,344	5,122	40-49	39,928,000	...	0.0242773
50-64	1,308,828	25,150	50-64	62,110,000	...	0.02107274
65-74	484,694	34,362	65-74	31,487,000	...	0.01539346
75-84	273,766	43,328	75-84	15,408,000	...	0.01776778
85+	189,286	52,028	85+	5,893,000	...	0.03212048
Total	6,360,770	163,081	Total	324,356,000	...	0.01961046

World Data

The World Data tab brings in data from the ourworld in data covid deaths website. It is used to populate the country and world data infections, deaths and fatality rates on the Extra Deaths sheet.

Links

The Links worksheet provides links to the Stats Canada, World Health Organization, and CDC websites, among others, where relevant information to update the spreadsheet can be found.

A key link for the Canadian data is: <https://health-infobase.canada.ca/covid-19/epidemiological-summary-covid-19-cases.html?redir=1>

[COVID-19 Situational Awareness Dashboard – Canada.ca](#)

The link for the world data is: <https://ourworldindata.org/covid-deaths>

Conclusion

At its core, the model predicts COVID-19 extra deaths for a given age, sex and region. It does so by applying fatality rates against population counts for the various constituencies. Those fatality rates are primarily obtainable from Stats Canada data. The CDC and other sources of data are used for comparison purposes only, as this is substantially a Canadian study. It is hoped that in time, more granular levels of detail will be publicly available.

The model as it currently stands is seen as a useful tool for actuaries modelling extra deaths in a format actuaries typically use with mortality tables. This level of detail includes deaths by age and sex within regions across Canada. Given the limited inputs to the model, the user should find it fairly user-friendly.

However, caution should be exercised, as in any model. This is an emerging pandemic and the ultimate assumptions and conclusions will not be known for some time. At the time of this writing, several other strains of this virus are emerging. It remains to be seen what impact those variants will have on any assumptions.

Users should feel free to incorporate other data and research as they model COVID-19 with this tool.