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Counting the Dead: COVID-19 and Mortality in Québec and British Columbia

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Abstract[1]

The first wave of the pandemic has led to excess mortality across the globe. Canada was no exception. But, the experience of provinces has been very different, and the objective of this paper is to investigate these differences focusing on two extreme cases. We contrast the mortality experience of British Columbia with that of Québec to understand how large differences in mortality during the pandemic emerged across these two provinces. We find that most of the differences can be found in excess mortality in institutions (nursing homes) and that both travel restrictions, differences in how deaths are recorded, differences in the seasonality of the flu or differences in how the pandemic spread across different economic segments of the population cannot explain these differences. We also document that the reported death toll from COVID is larger than excess mortality in Quebec, by about 30%, due to lower mortality from other causes of death, in particular malignant tumors, heart disease and respiratory problems.

Keywords: excess mortality, COVID-19, nursing homes, cause of death

JEL Codes: I18, J11

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1. Introduction

The pandemic has led to more than one million deaths worldwide as the time of writing this paper (World Health Organization[2]). There is considerable variation across countries in mortality due to the pandemic (Kontis et al., 2020; Beaney et al, 2020; Khafaie and Rahim, 2020; Goldstein and Lee, 2020).

The most reliable measure of the mortality burden of a pandemic is excess mortality which measures to extent to which total mortality (from all causes) deviates from expected mortality in the absence of the pandemic, based on historical data (Zylke and Bauchner, 2020; Viglione; Simonsen et al., 1998). This avoids comparing apple and oranges because countries may assign cause of death in different ways rendering comparisons difficult. Furthermore, excess mortality allows to look at indirect effects of the pandemic on mortality from other causes of death (Lange et al., 2020).

Some countries have very efficient death reporting systems, which allows to track mortality almost in real time. Canada is not one of those countries. Despite their best efforts, Canadian provinces have lagged in their mortality reporting by many months and some adjust their data for reporting and others do not. Although it is still hard to evaluate Canada's performance on a national basis relative to other countries, some provinces are doing better in terms of reporting deaths and Statistics Canada publishes data which is partially corrects for late reporting of cases based on historical data. Statistics Canada reports that Ontario and New Brunswick produce data with at least a 60 days delay while other provinces report within 30 days.

British Columbia and Quebec are two examples were data is typically reported to Statistics Canada within 30 days. Yet, their mortality experience during the pandemic could not be more different. According to provincial authorities, 6 214 COVID-19 deaths have been reported by

[2] https://www.who.int/emergencies/diseases/novel-coronavirus-2019

Quebec as of October 30th while the number of 263 in British Columbia (their population are respectively 8.4M and 5.7M). How can these numbers be so different, within the same country (Bignami and Van Assche, 2020), and in two provinces which otherwise have similar characteristics? This paper aims to answer this question.

We use micro data from the August 28th release of the Canadian Vital Statistics Database[3] (CVSD) of Statistics Canada (STC). We first look at the total number of deaths by week and province and discuss data quality in section 2. Overall, despite some differences, we find that Statistics Canada data for BC and QC, in particular in terms of first wave experience. Even if there is a difference between STC and the provincial statistical agency (ISQ) data for Quebec, the difference is minor (less than 5%). But the gap in total mortality between the two provinces is abysmal and using an excess mortality modelling exercise, we estimate excess mortality for both provinces using poisson models of weekly death counts. We then document differences in socio-economic characteristics, in travel restrictions and the strength of the flu season in both provinces. We find that although some of these differences may yield slightly higher mortality in Quebec, none of these factors is likely to explain the gap.

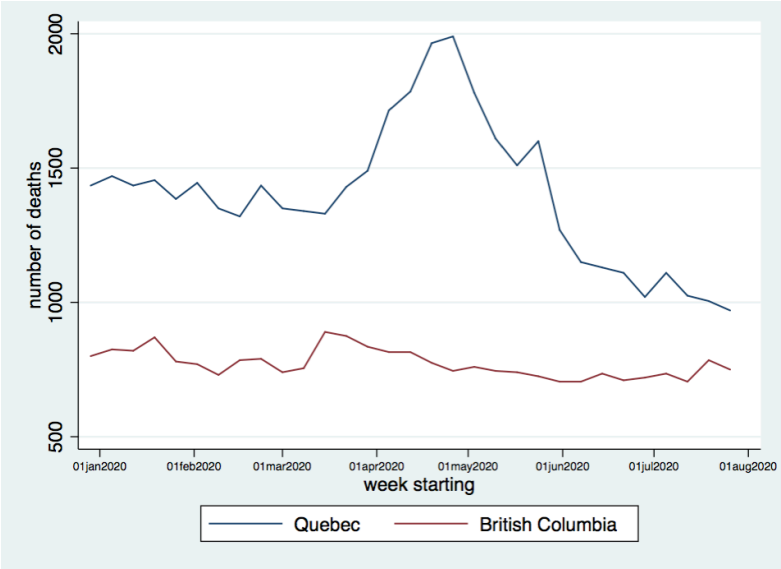
Next, we investigate differences in excess mortality by subgroups, such as age, place of death and income. The purpose is to drill down the source of these differences. We estimate that most of the gap is found in institutions (nursing homes). Given the already high mortality rate of this group, cumulative excess mortality is quite large with excess mortality rates increasing by 150% in Quebec but only 60% in British Columbia. We then discuss how reports of COVID deaths compare with excess death measures we compute. We find that for Quebec COVID deaths are larger than excess death. We show using cause of death data that this is because of a decrease in deaths due to other causes, in particular cancer, heart disease and respiratory problems.

[3] https://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3233

2. Overall Mortality in 2020

We use the August 28th 2020 release of the Canadian Vital Statistics Database (CVSD) which we accessed from one of the labs of the Canadian Research Data Center Network (QICSS). Mortality is reported up to August 8th 2020. We have the exact date of death for each death reported to Statistics Canada as well as a number of characteristics of each dead record, including gender, age, zip code and place of residence and death. We compute weekly death using the definition of weeks from the Center for Disease Control (CDC).[4] In Figure 1, we show unadjusted raw death counts directly computed from the data.

Figure 1 Weekly number of deaths in Quebec and British Columbia



Source: CVSD data (August 28th release).

[4] We use the epiweek package available in Stata (Chu, 2014).

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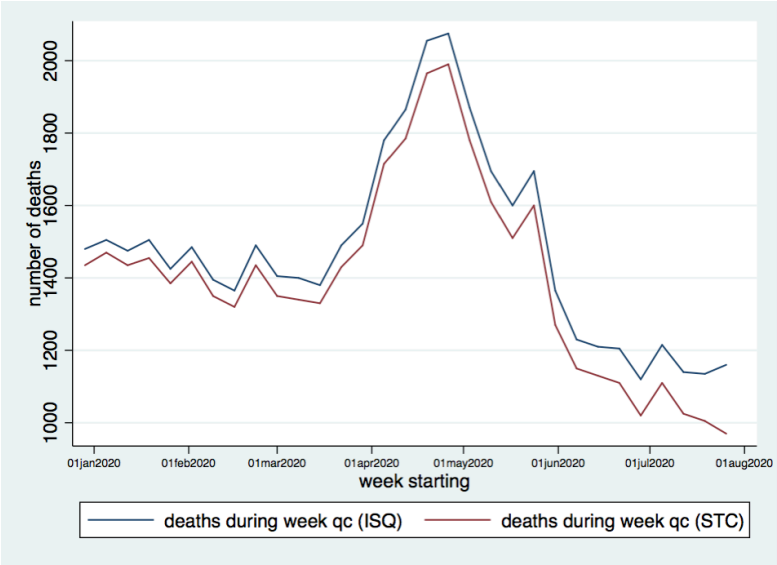
At the time of writing this paper, we do not adjust for reporting delays using the reporting delay factors by week computed by Statistics Canada for both provinces.[5] One way to check the effect of reporting delay adjustments is to compare our mortality series to that produced by a statistical agency that adjusts counts for reporting delays. The Quebec Statistical Agency (ISQ) also produces its own reporting delay model to report deaths per week[6]. In the Figure below, we compare the CVSD and ISQ weekly counts. Overall, there is little difference between those numbers till June, other than a slight level shift whereas we slightly under-estimate mortality with CSVD data. The differences can be explained by data transmission delay and the fact that both source have their particular adjustment method to take into account the database completeness[7][8].

Figure 2 Comparison of Weekly Death Counts in Quebec: CVSD and ISQ



Source: CVSD data (August 28th release) and data from ISQ.

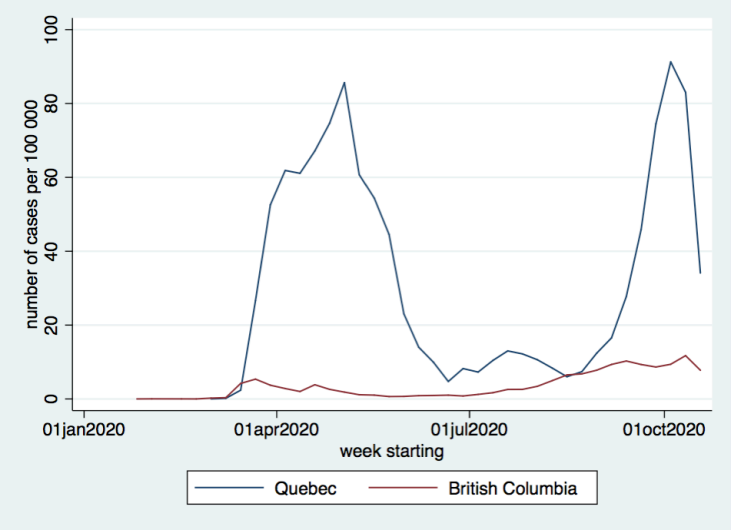
[5] Statistics Canada publishes estimates of excess deaths which include adjustments for delays. We have requested access to the reporting adjustments and these will be included in the future. We expect this to have a minor effect for our focus on the first wave.
[6] https://www.stat.gouv.qc.ca/statistiques/population-demographie/deces-mortalite/nombre-hebdomadaire-deces_an.html
[7] https://www.statcan.gc.ca/eng/statistical-programs/document/3233_D5_V1
[8] https://www.stat.gouv.qc.ca/statistiques/population-demographie/deces-mortalite/nombre-hebdomadaire-deces_an.html#notes

In comparison, unadjusted data from Ontario shows a rapidly declining pattern of deaths, starting in June which is likely due to the fact that reporting usually takes place 2 months after the death occurred. Hence, we focus on BC and Quebec for our analysis.

3. COVID-19, the Flu and Spring Break

The extent to which the virus affected both provinces is of course likely to be in part responsible for the different death toll across provinces. Figure 3 shows the number of cases reported in both provinces over time. Clearly, the number of cases, per 100 000, is much higher in Quebec and British Columbia.

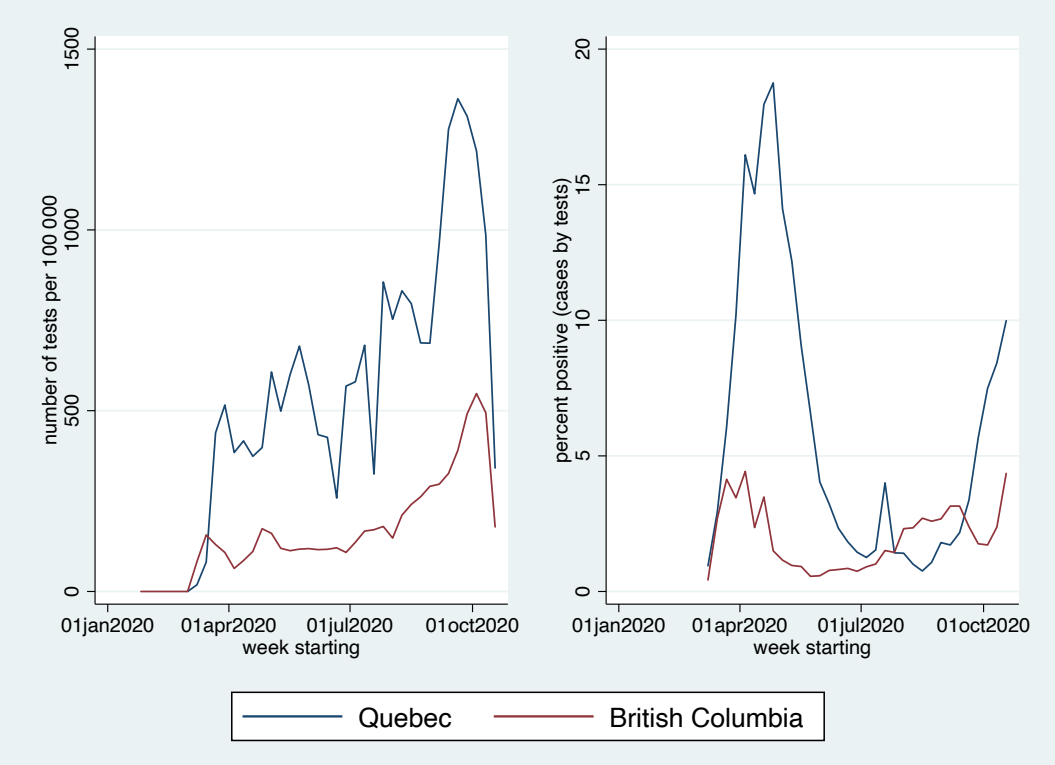
Figure 3 Number of COVID-19 cases detected per 100 000



Source: COVID-19 STC data accessed October 2020. The number of cases is expressed per 100 000 individuals.

If we consider tests, it is true that Quebec has tested much more than British Columbia (left panel of Figure 4). But the fraction of cases detected to tests per week shows that the fraction positive was much higher in Quebec than it was in BC (right panel of Figure 4). Because of differences in test strategies, we do not make much more of these data, other than conclude that the total mortality data is consistent with the pandemic hitting harder in Quebec than in BC.

Figure 4 COVID-19 Tests per 100 000 and Fraction Positive

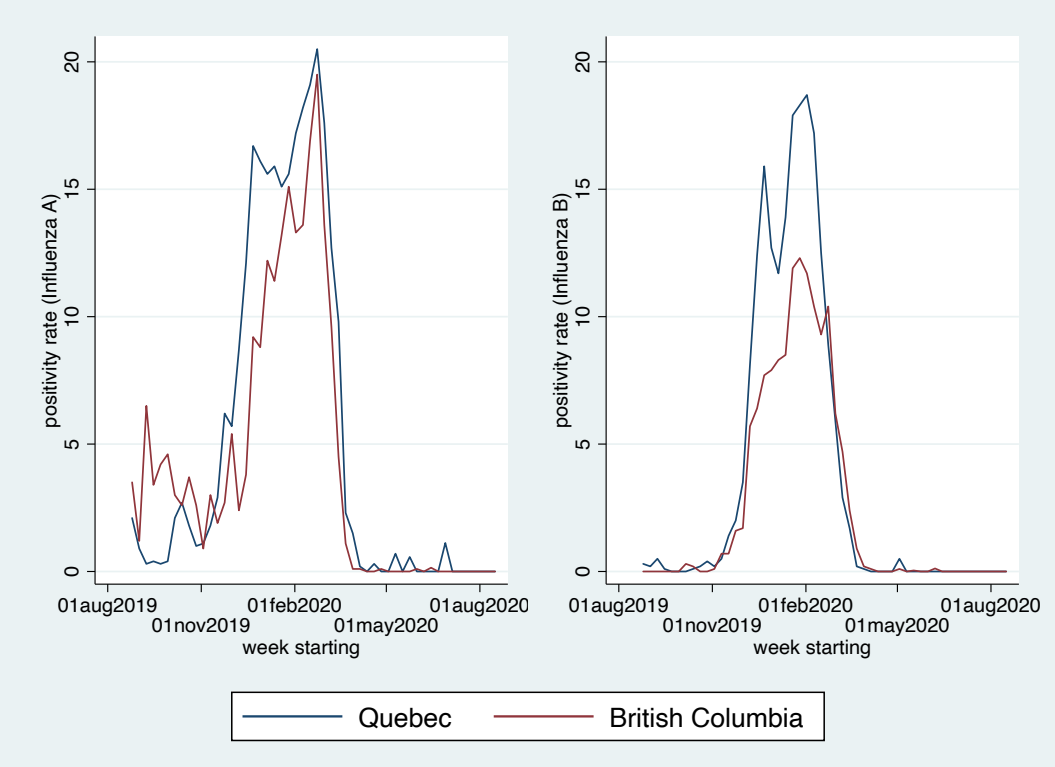


Source: STC Covid-19 Data accessed October 2020. The left panel shows the number of tests per 100 000 of population while the right panel shows the ratio of the number of weekly cases to the number of tests.

The seasonal flu is a key determinant of seasonal movements in mortality, in particular in the winter months (Troeger et al., 2019; Acosta et al., 2019; Payeur, 2017). Although it is highly improbable that differences in flu dynamics explain differences in mortality across these two provinces in the

spring, we use data from the Flu Watcher program[9] to show in Figure 5 the fraction of tests that returned positive for Influenza type A and B. For Type A, there is some evidence that the fraction positive was higher in Quebec in the late fall but had returned to similar levels by late April. As for Type B, positivity rates were higher in Quebec than in BC over the entire season. But the rates are similar starting in March and plummet in April.

Figure 5 Percent Positive for Influenza in 2019-2020 Flu Season



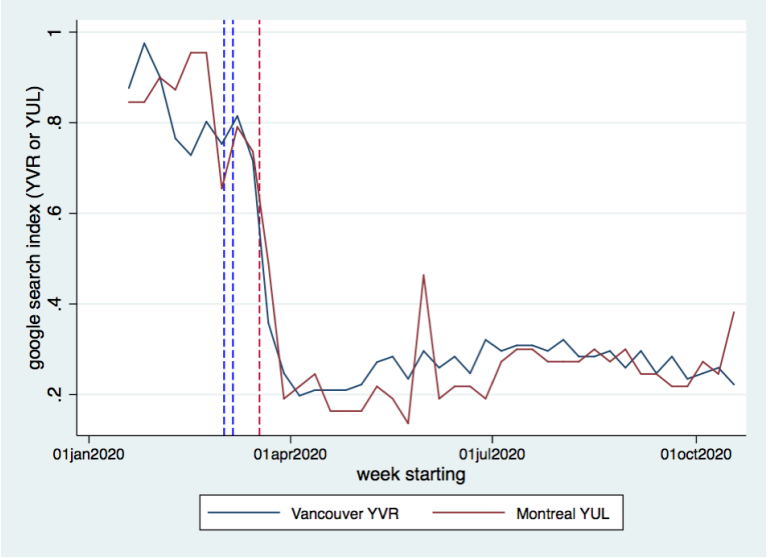
Source: Flu Watch Data accessed October 2020. The left panel shows positivity rate for Influenza A while the right panel shows positivity rates for Influenza B.

It was often mentioned in the media that the spring break in Quebec was later than in other provinces. Indeed, Quebec's spring break varies across schools but a large fraction of public schools, in the region of Montreal had their spring break in the week of March 2nd to 6th. In

[9] https://www.canada.ca/en/public-health/services/diseases/flu-influenza/influenza-surveillance.html

comparison, spring break was in late March in British Columbia, after the start of the epidemic. Hence, this could be one of the factors why the virus spread more quickly in Quebec, for example if people travelled more around this time. Yet, this had very little effect on how air travel evolved over the weeks preceding and following the imposition of travel bans in Canada. Data on the number of passengers at major airports is not available at the weekly level. Hence, we use the Google search index for YVR (Vancouver airport) and YUL (Montreal airport). In Figure 6, we show that the index did not drop at a different pace across airports (the index is normalized to the level for January). There is some indication of a blimp in searchers for YUL in mid-February, before spring break which could be correlated with elevated travel volume but cannot explain the interprovincial heterogeneity (Khomsi et al. 2020; Godin et al., 2020).

Figure 6 Google search index for Airports in Both Provinces



Source: Google search index API, accessed October 12th 2020. Blue Dashed lines represent start and end of Quebec's Spring Break (Montreal, Outaouais and Laurentides) while the red dashed line marks March 18th where the Federal Government banned international flight arrivals (except U.S.).

4. Excess Mortality

We use data from 2015 to 2020 from the CVSD. We group mortality at the weekly level (epidemiological week). We model the count of the number of weekly deaths using a Poisson process with multiplicative expectation in week and year fixed effects,

$$\lambda_{w,t} = e^{\gamma_t} e^{\gamma_w}.$$

We estimate fixed effects over data from January 2015 to the 1st of Match 2020. We choose a simple fixed effect specification in order to avoid specifying a functional form for the year and month trends. Denote by $d_{w,t}$ the number of deaths in week w of year t.[10] In the literature, there is a number of ways of computing weekly excess mortality (Noufaily et al., 2012; Maëlle et al., 2014; Xie et al., 2014; Aron et al., 2020; Adair et al., 2020; Choinière, 2020; Statistique Canada 2020; Michaud, 2020). One is to simply look at the deviation between the actual number of deaths and the expected number of deaths, or

$$E^1_{w,t} = max\left(d_{w,t} - \lambda_{w,t}, 0\right)$$

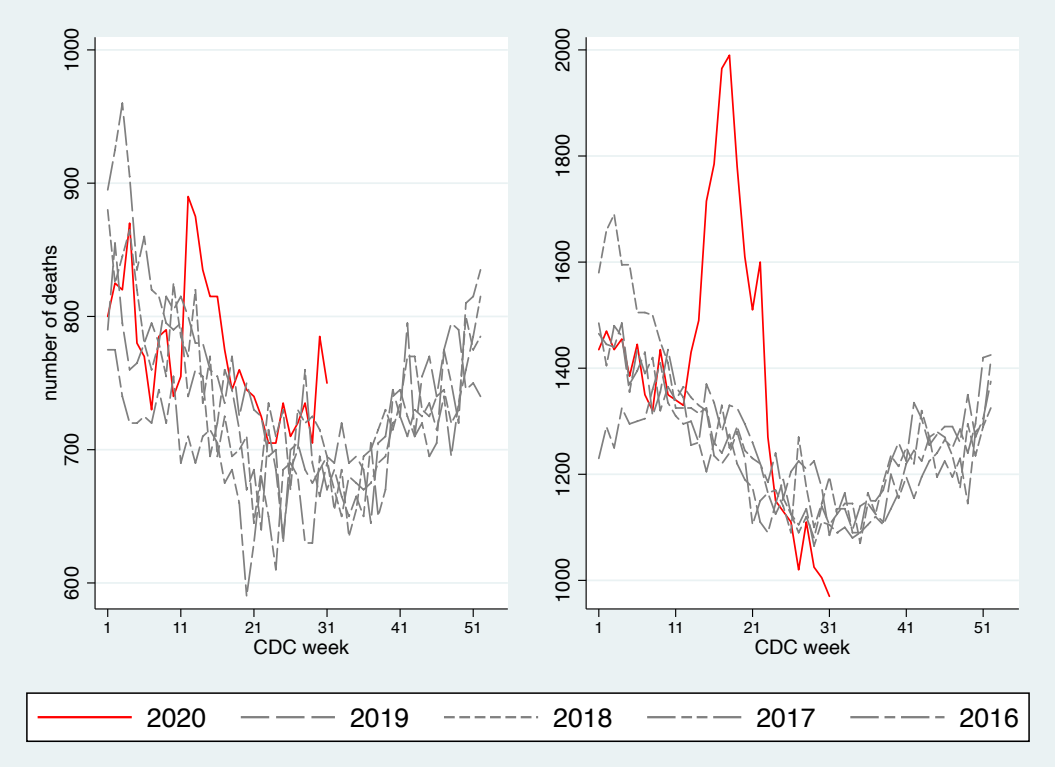
Another is to use the upper bound of the 95th confidence interval of $\lambda_{w,t}$ and only count deaths above that threshold,

$$E^2_{w,t} = max\left(d_{w,t} - \lambda^U_{w,t}, 0\right)$$

[10] A negative binomial specification gives similar estimates for excess death while a log linear specification also gives similar results. This is expected given a correct specification of the conditional specification of deaths, quasi maximum likelihood is consistent for the fixed effects if the true process has a distribution from the linear exponential family. Confidence intervals vary being slightly across specifications. In what follows, we use the poisson specification. Estimates using other specifications are available upon request.

where $\lambda_{w,t}^{U}$ is the upper bound of the confidence interval. In Figure 7, we first show the historical number of deaths by week and year for Quebec and British Columbia. Generally, mortality is higher at the beginning and end of the year and reaching a minimum somewhere in the summer months. The year 2020 clearly stands out for British Columbia but especially Quebec. We estimate poisson models for both Quebec and British Columbia over the pre-COVID period (prior to March 1st 2020).

Figure 7 Historical Data on Weekly Mortality for Quebec and British Columbia

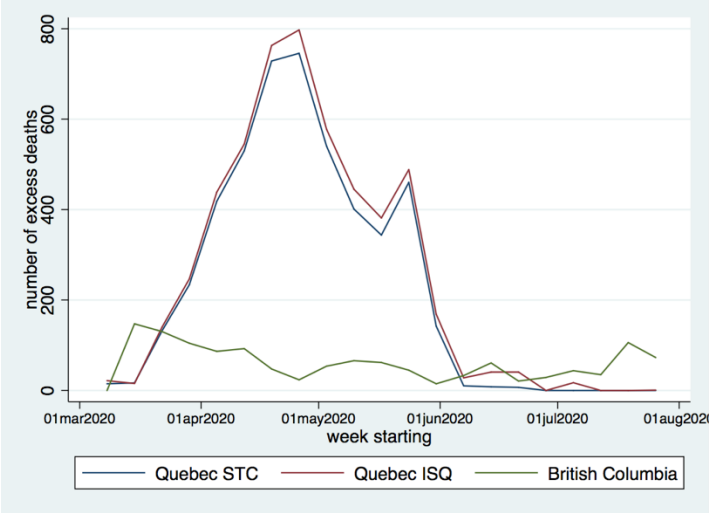


Source: CVSD data. The left-panel shows data for British Columbia while the right panel shows data for Quebec.

In Figure 8, we plot the E^1 measure of excess mortality using the average predicted count. We do this using both CVSD data for Quebec and British Columbia as well as using data from ISQ for Quebec. The picture is quite clear: excess mortality was much higher in Quebec than it was in

British Columbia. Interestingly however, excess mortality started being observed earlier in British Columbia than in Quebec.

Figure 8 Excess Mortality in Quebec and British Columbia



Source: CVSD and ISQ data.

In Table 1, we compare the cumulative total number of excess deaths in Quebec and British Columbia using the two measures of excess mortality (at the mean and above the upper bound of the confidence interval).

Table 1 Total Excess Deaths March to July 2020

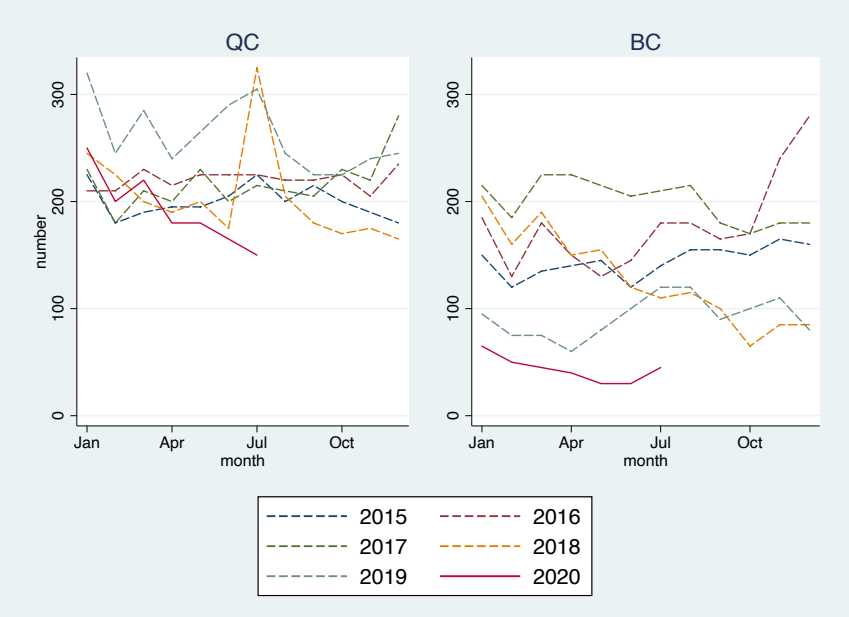
Province or Data	Total Excess above the average	Total Excess above CI
Quebec: CVSD	4732.4	3921.6
Quebec: ISQ	5295.8	4227.9
British Columbia: CVSD	1273.8	409.47

Source: Excess counts are computed using poisson regressions and two measures of excess mortality. In the first data column, we show the cumulative total number of excess deaths using excess above the expected number of deaths (counting negative excess deaths as zero). In the second column, excess deaths are computed relative to the upper bound of the 95th percent confidence interval for the expected number of counts.

Compared with declared number of COVID deaths, these numbers for excess deaths are lower. This is interesting and may suggest three underlying mechanisms: 1) other causes of deaths went down, say because of reduced economic activity (Peeples, 2019; Strumpf et al., 2017) or 2) some deaths that would have been assigned another cause were assigned COVID (Woolf et al., 2020) or 3) those who died of COVID would have died anyway from other causes during the same period (Luy et al, 2020; Toulemon and Barbieri; 2008). To investigate, we use cause of death data reported by Statistics Canada at the monthly level. Because data for July 2020 is incomplete, we stop in June (Statistics Canada, 2020b).

One example of a potentially negative effect of deaths is accidents. As Figure 9 shows, deaths from accidents were down in both Quebec and British Columbia during the first wave. But for causes of death associated with the elderly, a particularly heavily hit group as well will see later, there is also a decrease in the number of deaths, most notably in Quebec. In Figure 10 we show for QC and BC the evolution of deaths from Malignant tumors, heart disease and respiratory problems. We see, particularly in Quebec, a quite abrupt drop for Malignant tumors and respiratory problems. To quantify the importance of these effects, we perform an accounting exercise.

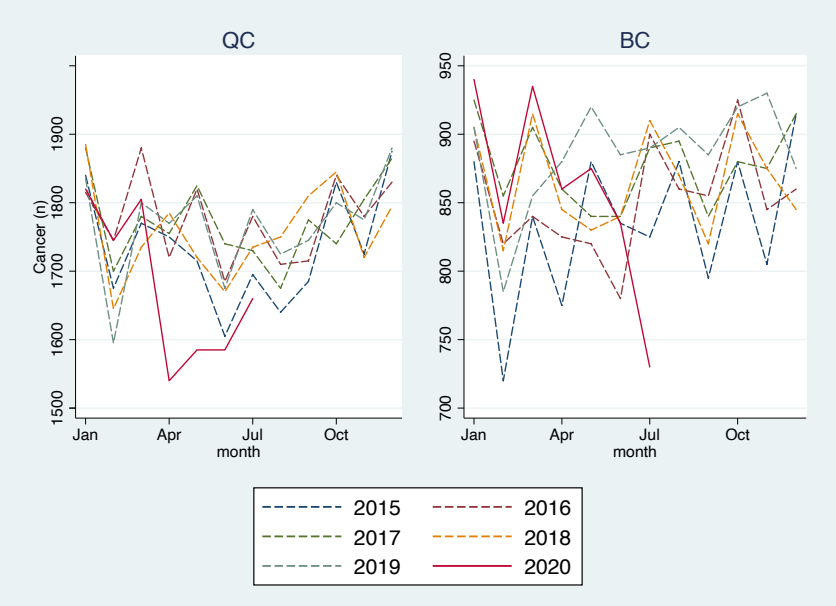
Figure 9 Number of deaths by accidents in Quebec and British Columbia



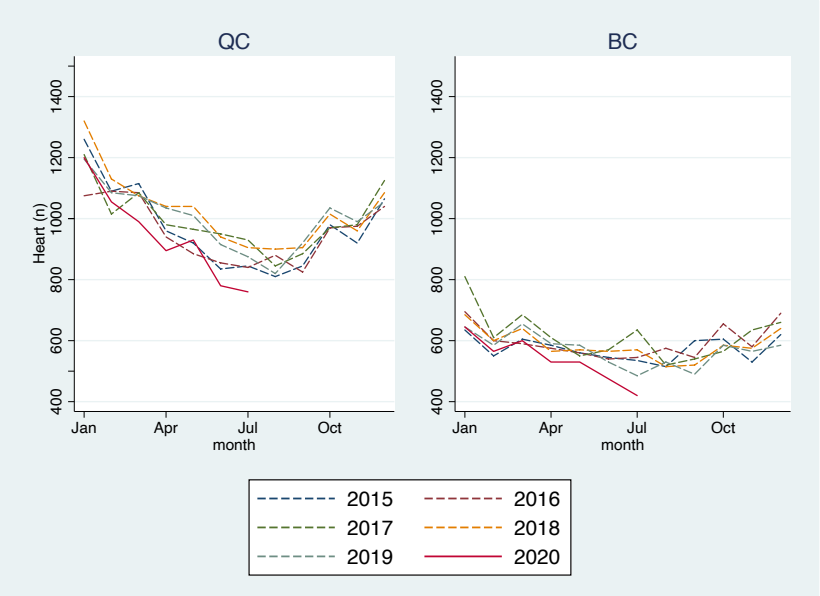
Source: CVSD data for British Columbia (left panel) and Quebec (right panel).

Figure 10 Number of deaths by selected causes in Quebec and British Columbia

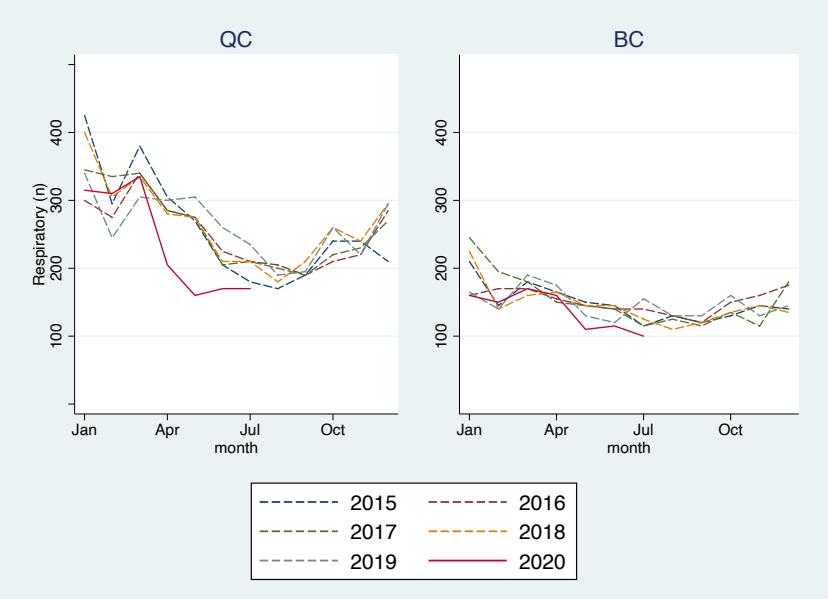
Malignant Tumors



Heart disease



Respiratory Problems



Source: CVSD data for Quebec (left panel) and British Columbia (right panel).

We first compute excess deaths for each of the 12 causes of death using Poisson models at the monthly level. We also re-estimate the poisson regression for total number of deaths at the monthly level. As we show in Table 2, excess mortality for Total deaths is 760.2 for BC and 4322.1 for QC,

lower at the monthly level than at the weekly level. The reported number of deaths from COVID in these data are 170 for BC and 6060 for QC. If we sum the excess mortality for other causes of death we get a positive number for BC (242 deaths) while we get -1 836 deaths for Quebec. The number of reported deaths from Cancer is 570 lower in Quebec from March to June. We see similar decrease for almost all causes of death in Quebec. This suggest that cause of death was assigned generously to COVID-19 (particularly for causes with symptoms similar to those of the virus) or that individuals who got COVID-19 were very likely to die within this period from one of these conditions (most vulnerable older individuals). It is difficult to separate these effects. For British Columbia, there is the potential for the total death toll from COVID to be under-estimated because the cause of death for a significant number of deaths is left unspecified (206.7). We also observe that the total of excess non-COVID and COVID deaths and the excess mortality from all deaths are similar for Québec (more or less 100 deaths).

Table 2 Excess Mortality by Cause of Death and COVID Deaths

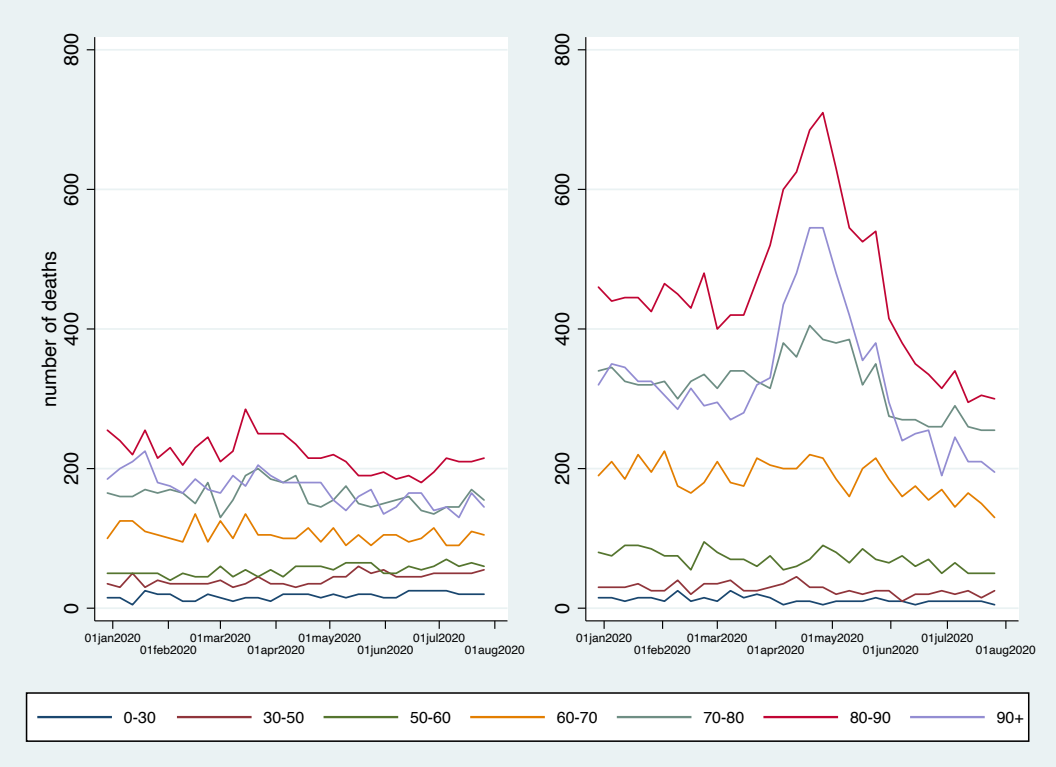
Causes	BC	QC
Excess mortality for		
Accidents	-77.8	-120.3
Alzheimer	29.3	-38.5
Cancer	-45.0	-570.5
Cerebrovascular	-53.6	-127.1
Diabetes	29.1	-48.1
Flu and pneumonia	-0.8	-100.4
Heart disease	-67.1	-279.0
Non-specified	206.7	-6.1
Nephropathy	9.3	-46.6
Other	245.8	-134.1
Respiratory	20.5	-213.5
Suicide	-54.6	-151.3
Total of excess non-Covid deaths	241.7	-1835.5
Covid deaths	170.0	6060.0
Total of excess non-Covid and Covid deaths	411.7	4224.5
Excess mortality from Total deaths	760.2	4322.1

Source: Statistics Canada monthly cause of death data from January 2015 to June 2020. Excess mortality is computed from a poisson model with month and year fixed effects. This is done for each cause of death in each province. Both positive and negative excess mortality is counted.

4.1 Excess Mortality by Age

In Figure 11, we show the number of deaths weekly by age groups. Excess mortality is apparent mostly for those 70+, both in Quebec and for BC. For BC, we see that the early peak during the pandemic is mostly the result of elevated mortality among the 80 to 90 years old group. In Quebec, the entire 70+ group experiences excess mortality.

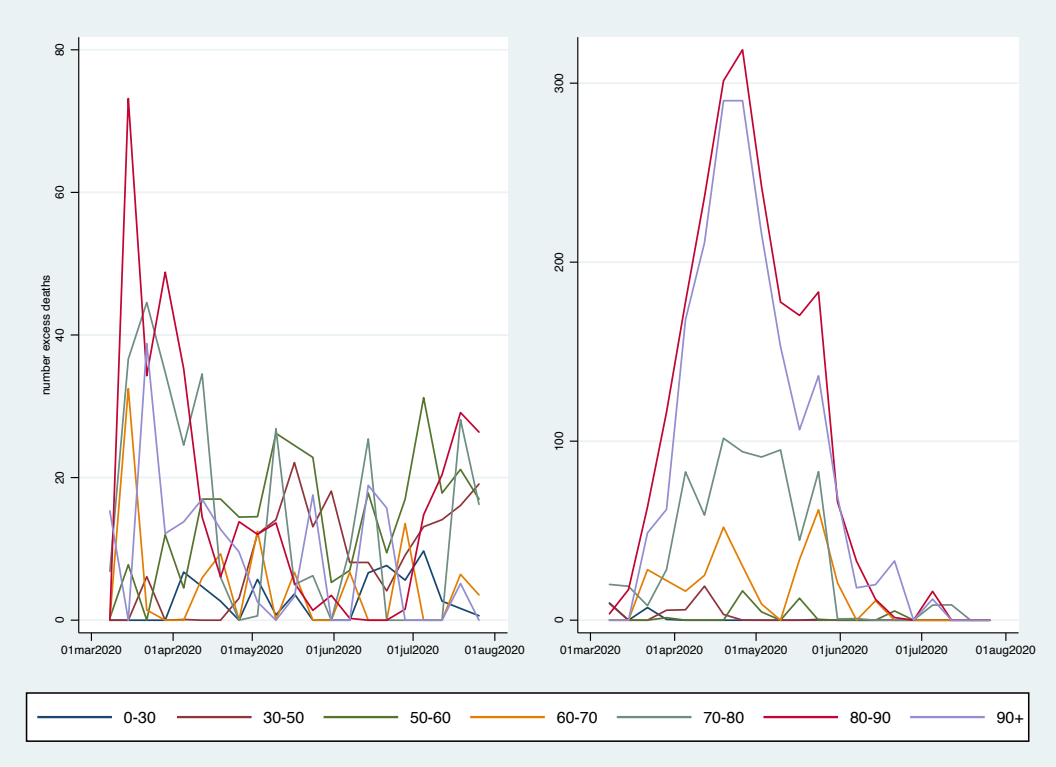
Figure 11 Weekly Mortality by Age Group



Source: CVSD data for British Columbia (left panel) and Quebec (right panel).

We perform excess mortality calculations for each age group, which accounts for seasonal shifts in mortality by age group. We report excess mortality in percentage terms to grasp the relative increase in mortality by age groups. In Figure 12, we show that while excess mortality is present in BC and Quebec, the scale of the increase is quite different among the elderly. While deaths increase by 70% in the early days of the pandemic in BC, the increase in Quebec reaches 300% (hence 4 times) the number of deaths typically observed for those 80 to 90 years old and 90+. For those between age 70 and 80 is more modest.

Figure 12 Excess Mortality by Age Group



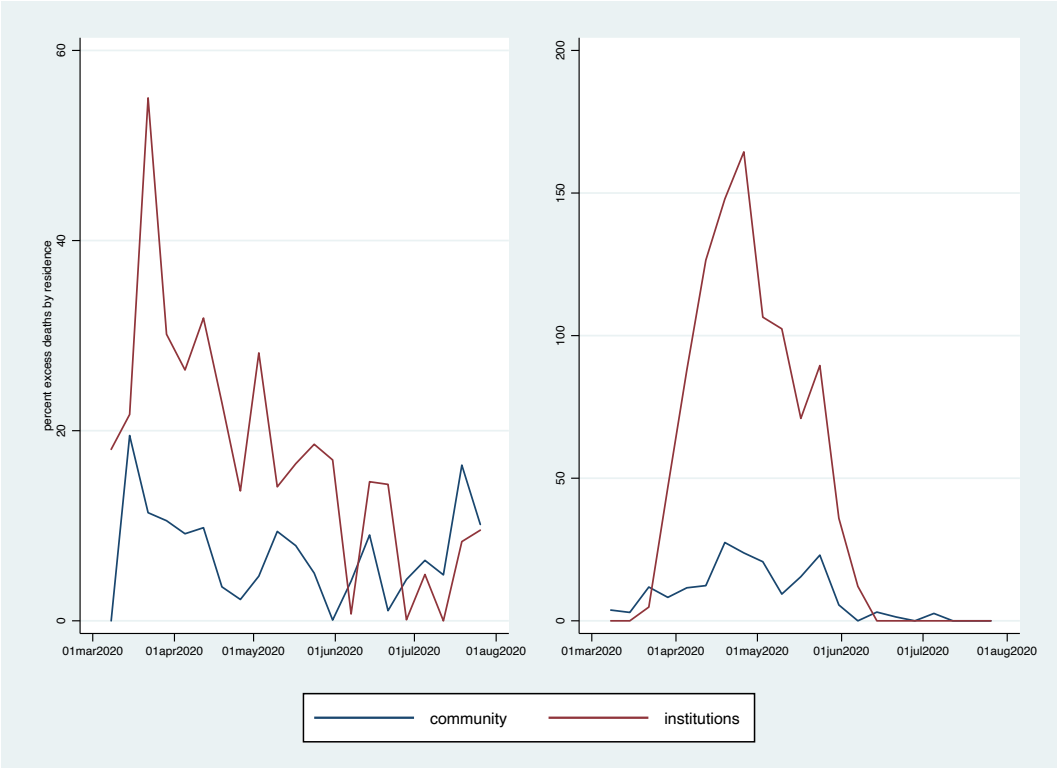
Source: CVSD data for British Columbia (left panel) and Quebec (right panel). Excess mortality obtained using Poisson regression models with week and year fixed effects.

5. Deaths in Institutions

Since most of the deaths occurred in older age groups, we can assess whether these occurred in institutions or not and estimate the extent of excess mortality. Mortality rates are high in nursing homes and therefore we want to know by how much did mortality rates increase in nursing homes. The CVSD contains information in the place of death. In Figure 13, we show excess mortality (in percent) for those dying in nursing homes and outside nursing homes. Interestingly, excess mortality occurs in both settings in BC at the beginning of the pandemic. While excess mortality is

higher (in relative terms) in institutions, there is a 20% increase in mortality in the community as well. In Quebec, there is no such increase at the beginning of the pandemic. Instead, excess mortality in institutions starts appearing later in March. At the peak of the pandemic, excess mortality represents an increase if more than 150% in mortality rates in institutional settings (hence 2.5 times what is observed normally).

Figure 13 Excess Mortality by Place of Death



Source: CVSD data for British Columbia (left panel) and Quebec (right panel). Excess mortality relative to expected count using Poisson regressions with month and year fixed effects by place of death (institutions vs. community).

It is important to understand why these differences in institutions came about. Some evidence from comparing the Ontario to the BC response to the pandemic as identified as key the decision of BC health officials to prohibit movement of personnel across nursing homes (Liu et al., 2020). We

think that understanding how the pandemic creeped into nursing homes in Quebec should be a research priority.

5.1 Excess Mortality by Income

In terms of cases, it has been documented that the pandemic was hitting harder poorer neighborhoods (Choi et al., 2020; McKie, 2020; Chen and Krieger, 2020). An interesting question is whether that this translated into a higher mortality burden. The CVSD has postal code information for each death. Until 2011, information on household income quintile of the neighborhood was included in the dataset. Since the rank of neighborhoods in terms of income is unlikely to change much over the last 10 years, we use that measure of income for the period 2015-2020 to look at excess mortality.[11] We perform excess mortality poisson regressions by income quintiles for both QC and BC. Table 3 shows the cumulative number of excess deaths by income quintiles for QC and BC.

Table 3 Cumulative Excess deaths by Income quintiles

Income Quintile	Quebec	British Columbia
Q1	1115	223
Q2	890	160
Q3	887	193
Q4	654	114
Q5	573	105
Total	4209	795

Source: CVSD data for British Columbia (left panel) and Quebec (right panel). Excess mortality relative to expected count using Poisson regressions with month and year fixed effects by income quintile.

[11] Not all postal codes in 2015-2020 have a match to the 2011 postal code series for income quintile. Among those without a match (roughly 33%), there does not appear to be excess deaths in poisson regressions. Results available upon request.

The mortality burden of the pandemic has fallen disproportionately more on lower income neighborhoods. In both provinces, more than 25% of the excess deaths are associated to the first income quintile compared to less than 15% for the higher quintile. This discrepancy can be, in part, explain by working conditions that leave people more exposed to the virus and smaller dwellings and is the reflect of a more general health disparity observed not only during the pandemic (Woolf and Braveman, 2011; Frohlich et al., 2006). However, it is important to know that in relative terms, as a fraction of expected mortality, excess mortality is similar for the bottom 3 quintiles of the distribution with some evidence of lower increase in richer neighborhoods.

6. Conclusion

In this paper, we show how the first wave of COVID-19 hit hard in Quebec compared to British-Columbia. Explanations having to do with spring break and the flu cannot explain these differences. Instead, the results show that, in terms of mortality in Québec, persons aged 80 years old and over and those living in a nursing home were much more affected. For those aged over 80, the excess reaches 300% of the number of deaths typically observed. For those living in a nursing home, the excess mortality represents an increase of more than 150% of the expected values at the peak of the pandemic and it represents 6 times the excess deaths of those living in private household compared to 3 times in British-Colombia. We reconcile the difference between COVID reported deaths by the health agency in Quebec and estimates of excess death by nothing that mortality from other causes of death went down, rather than up, during the pandemic. This could signal that those who died of COVID would have died of other cause, or that perhaps COVID was assigned as a cause of death for records were perhaps the cause of death was different. This negative non-COVID death is important and represents up to one third of the COVID-reported deaths in Quebec. In BC,

we find an increase during the pandemic in death from unknown causes, which could signal that COVID deaths were under-reported.

Even if we need to be cautious with kind of comparison dur to preliminary nature of the data, we think that we can learn from some practices in place in other provinces to reduce the burden of upcoming waves for people living in institution. One could think of British Columbia as a good counterfactual of what would have happened if Quebec took measures quickly to avoid deaths and contagion in nursing homes. For example, it remains to be seen whether movement of personnel across nursing homes contributed to the spread of the virus in nursing homes, but casual observation from the Media suggest that it did. A number of missteps were identified and the government of Quebec has asked for an inquiry into what happened in nursing homes. If the BC counterfactual holds, then the excess death measured for Quebec relative to British Columbia serves as an estimate of the lives lost due to mismanagement in nursing homes. Once data becomes more complete, there is the potential to put a dollar number of the costs of mismanagement in nursing homes using those estimates. Sidestepping the issue of assigning a value of life year to these estimates, one has to be careful to assign the correct number of years lost which could be an even more difficult task. Using mortality tables for the general population appears inadequate. If those that died in nursing homes were likely to die within the next weeks or so, then the number of years lost might be much smaller than if one uses mortality life tables to impute years lost.

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