Face Masks, Public Policies and Slowing the Spread of COVID-19: Evidence from Canada*

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Abstract

We estimate the impact of mask mandates and other non-pharmaceutical interventions (NPI) on COVID-19 case growth in Canada, including regulations on businesses and gatherings, school closures, travel and self-isolation, and long-term care homes. We partially account for behavioral responses using Google mobility data. Our identification approach exploits variation in the timing of indoor face mask mandates staggered over two months in the 34 public health regions in Ontario, Canada's most populous province. We find that, in the first few weeks after implementation, mask mandates are associated with a reduction of 25 percent in the weekly number of new COVID-19 cases. Additional analysis with province-level data provides corroborating evidence. Counterfactual policy simulations suggest that mandating indoor masks nationwide in early July could have reduced the weekly number of new cases in Canada by 25 to 40 percent in mid-August, which translates into 700 to 1,100 fewer cases per week.

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JEL codes: I18, I12, C23

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1 Introduction

When government policies to stem the spread of COVID-19 were introduced in early 2020, the best available evidence supporting them was provided by studies of previous epidemics, epidemiological modeling, and case studies (OECD, 2020). Even when the efficacy of a given precaution in reducing COVID-19 transmission has been established, significant doubts regarding the usefulness of specific policy measures may persist due to uncertainty regarding adherence to the rules and other behavioral responses. For example, even though several observational studies, mostly in medical setting, have shown that face masks reduce the transmission of COVID-19 and similar respiratory illnesses (see Chu et al. (2020) for a comprehensive review), a face mask mandate may not be effective in practice if it fails to increase the prevalence of mask wearing (compliance), or if it leads to increased contacts due to a false sense of security. It is therefore important to directly evaluate and quantify the relationship between various policy measures and the rate of propagation of COVID-19.

The low cost and high feasibility of mask mandates relative to other containment measures for COVID-19 has generated keen interest worldwide for studying their effectiveness. This attention has been compounded by substantial variation, across jurisdictions and over time, in official advice regarding the use of masks. Figure B1 in the Appendix plots self-reported mask usage in select countries (Canada, United States, Germany and Australia) in the left panel, and across Canadian provinces in the right panel. The figure shows large differences in mask usage, both across countries and within Canada.[1]

We estimate and quantify the impact of mask mandates and other non-pharmaceutical interventions (NPI) on the growth of the number of COVID-19 cases in Canada. Canadian data has the important advantage of allowing two complementary approaches to address our objective. First, we estimate the effect of mask mandates by exploiting within-province geographic variation in the timing of indoor face mask mandates across 34 public health regions (PHUs) in Ontario, Canada's most populous province with a population of nearly 15 million or roughly 39% of Canada's population (Statistics Canada, 2020). The advantage of this approach is that it exploits variation over a relatively small geographic scale (PHU), holding all other province-level policies or events constant. In addition, the adoption of indoor face mask mandates in these 34 sub-regions was staggered over approximately two months, creating sufficient intertemporal policy variation across the PHUs.

[1] We show mask usage for the U.S. and Germany because related work by Chernozhukov et al. (2020) and Mitze et al. (2020) studies the effect of mask mandates in these countries respectively. We show Australia as an example of a country which did not mandate mask usage, except for Melbourne in late July. See Hatzius et al. (2020) for more cross-country comparisons of mask usage.

Second, we evaluate the impact of NPIs in Canada as a whole, by exploiting variation in the timing of policies across the country's ten provinces. By studying inter-provincial variation, we are able to analyze the impact of not only mask mandates, but also other NPIs, for which there is little or no variation across Ontario's PHUs (regulations on businesses and gatherings, schooling, travel and long-term care). In addition, our province-level data include both the closing period (March-April) and the gradual re-opening period (May-August), providing variation from both the imposition and the relaxation of policies.

Our panel-data estimation strategy broadly follows the approach of Chernozhukov, Kasahara and Schrimpf (2020), hereafter CKS (2020), adapted to the Canadian context. We allow for behavioural responses (using Google Community Mobility Reports geo-location data as proxy for behaviour changes and trends), as well as lagged outcome responses to policy and behavioral changes. Our empirical approach also allows current epidemiological outcomes to depend on past outcomes, as an information variable affecting past policies or behaviour, or directly, as in the SIR model framework.

We find that, in the first few weeks after their introduction, mask mandates are associated with an average reduction of 25 to 31% in the weekly number of newly diagnosed COVID-19 cases in Ontario, holding all else equal. We find corroborating evidence in the province-level analysis, with a 36 to 46% reduction in weekly cases, depending on the empirical specification. Furthermore, using survey data, we show that mask mandates increase self-reported mask usage in Canada by 30 percentage points, suggesting that the policy has a significant impact on behaviour. Jointly, these results suggest that mandating indoor mask wear in public places is a powerful policy measure to slow the spread of COVID-19, with little associated economic disruption at least in the short run.[2]

Counterfactual policy simulations using our empirical estimates suggest that mandating indoor masks nationwide in early July could have reduced weekly new cases in Canada by 25 to 40% on average by mid-August relative to the actually observed numbers, which translates into 700 to 1,100 fewer cases per week.

We also find that the most stringent restrictions on businesses and gatherings observed in our data are associated with a decrease of 48 to 57% in weekly cases, relative to a lack of restrictions. The business/gathering estimates are, however, noisier than our estimates for mask mandates and do not retain statistical significance in all specifications; they appear driven by the smaller provinces and the re-opening period (May to August). School closures and travel restrictions are associated with a large decrease in weekly case growth in the

[2] Hatzius et al. (2020) estimate that a national mask mandate in the USA could replace alternative restrictions costing 5% of GDP.

closing period. Our results on business/gathering regulations and school closure suggest that reduced restrictions and the associated increase in business or workplace activity and gatherings or school re-opening can offset, in whole or in part, the estimated effect of mask mandates on COVID-19 case growth, both in our sample and subsequently.

An additional contribution of this research project is to assemble, from original official sources only, and make publicly available a complete dataset of COVID-19 cases, deaths, tests and policy measures in all 10 Canadian provinces.[3] To this end, we constructed, based on official public health orders and announcements, time series for 17 policy indicators regarding face masks, regulations on businesses and gatherings, school closures, travel and self-isolation, and long-term care homes.

Our paper relates most closely to two recent empirical papers on the effects of mask mandates using observational data.[4] CKS (2020) and Mitze et al. (2020) study the effect of mask mandates in the United States and Germany, respectively. CKS (2020), whose estimation strategy we follow, exploit U.S. state-level variation in the timing of mask mandates for employees in public-facing businesses, and find that these mandates are associated with 9 to 10 percentage points reduction in the weekly growth rate of cases. This is substantially smaller that our estimates, possibly because the mask mandates that we study are much broader: they apply to all persons rather than just employees, and most apply to all indoor public spaces rather than just businesses. Mitze et al. (2020) use a synthetic control approach and compare the city of Jena and six regions in Germany that adopted a face mask policy in early to mid April 2020, before their respective state mandate. They find that mandatory masks reduce the daily growth rate of cases by about 40%.

Our paper has several advantages compared to the above two papers. First, we exploit both regional variation within the same province (like Mitze et al., 2020) and provincial variation in the whole country (like CKS, 2020), and find similar results, which strengthens the validity of our findings. Second, we show that self-reported mask usage has increased after introducing mask mandates. We view this "first-stage" result on mask usage as informative, as the effectiveness of any NPI or public policy critically depends on the compliance rate. Moreover, this result mitigates possible concerns that the estimated mask mandate effect on COVID-19 case growth may be caused by factors other than mask policy. Third, a key

[3] All data are available for download at https://github.com/C19-SFU-Econ. The COVID-19 cases, deaths and tests data that we collected and use in this paper incorporate all official ex-post revisions as of mid-August, unlike data from the Government of Canada COVID-19 website or other aggregator websites.

[4] Howard et al. (2020), a comprehensive review of the medical literature, stresses that "no randomized controlled trial (RCT) on the use of masks as source control for SARS-CoV-2 has been published." It is unlikely that an RCT on masks' effectiveness against COVID-19 will be feasible or ethical during the pandemic.

difference between our paper and CKS (2020) is that we evaluate the effect of *universal* (or *community*) mandatory indoor mask wearing for the public rather than the effect of mandatory mask wearing for *employees only*.[5] While other factors such as differences in mask wear compliance between Canada and the U.S. may contribute to the different estimated magnitude of the policy impact, our results suggest that more comprehensive mask policies can be more effective in reducing the case growth rate.

Other Related Literature

Abaluck et al. (2020) discuss the effectiveness of universal adoption of homemade cloth face masks and conclude that this policy could yield large benefits, in the \$3,000–\$6,000 per capita range, by slowing the spread of the virus. The analysis compares countries with pre-existing norms that sick people should wear masks (South Korea, Japan, Hong Kong and Taiwan) and countries without such norms.[6]

In the medical literature, Prather et al. (2020) argue that masks can play an important role in reducing the spread of COVID-19. Howard et al. (2020) survey the medical evidence on mask efficiency and recommend public use of masks in conjunction with existing hygiene, distancing, and contact tracing strategies. Greenhalgh et al. (2020) provide evidence on the use of masks during non-COVID epidemics (influenza and SARS) and conclude that even limited protection could prevent some transmission of COVID-19. Leung et al. (2020) study exhaled breath and coughs of children and adults with acute respiratory illness and conclude that the use of surgical face masks could prevent the transmission of the human coronavirus and influenza virus from symptomatic individuals. Meyerowitz et al. (2020) present a recent comprehensive review of the evidence on transmission of the virus and conclude that there is strong evidence from case and cluster reports indicating that respiratory transmission is dominant, with proximity and ventilation being key determinants of transmission risk, as opposed to direct contact or fomite transmission.

Our paper also complements recent work on COVID-19 policies in Canada. Mohammed et al. (2020) use public opinion survey data to study the effect of changes in mask-wear policy recommendations, from discouraged to mandatory, on the rates of mask adoption and public trust in government institutions. They show that Canadians exhibit high compliance with mask mandates and trust in public health officials remained consistent across time. Yuksel et al. (2020) use an outcome variable constructed from Apple mobility data along

[5] Lyu and Wehby (2020) provide suggestive evidence that community mask mandates are more effective than employees-only mandates.

[6] The authors report average daily case growth rate of 18% in countries with no pre-existing mask norms vs. 10% in countries with such norms. On a weekly basis, this translates to a reduction of 49 log points $(100(\log(1.18^7) - \log(1.1^7)))$ in case growth, or 39% reduction in weekly cases.

with weather data and lagged COVID-19 cases or deaths as dependent variables to study compliance with social distancing measures.

2 Data

We use three main data sources, respectively for epidemiological variables, NPI and mask mandates, and behavioral responses. The time period is from the start of detected community transmission in Canada in March to mid-August, 2020.

We located and accessed the original official sources to collect a complete dataset of COVID-19 cases, deaths, tests and policy measures in all ten Canadian provinces.[7] In addition, our data include cases and policy measure indicators for each of the 34 public health units (PHUs) in Ontario. A detailed description is provided in the data source files shared at the project's Github webpage.

Implementation dates of NPIs and other public policies were collected from government websites, announcements, public health orders and staged re-opening plans collected from their official sources. In the national data, the raw policy measures data contain the dates or enactment and relaxation (if applicable) of 17 policy indicators including: mandatory mask wear; closure and re-opening of retail and non-essential businesses, restaurants, recreation facilities, and places of worship; school closures; limits on events and gatherings; international and domestic travel restrictions and self-isolation requirements; restrictions on visits and staff movement in long-term care homes. All policy indicator variables are defined in Table C1 in the Appendix.[8] Since many of these indicators are highly correlated with each other, we combine them into five policy aggregates in the empirical analysis (see Table A17 and Section 3.2). In the Ontario PHU data, the implementation dates of mask mandates and the relaxation dates of policies for businesses and gatherings vary across PHUs. Decisions about the former were made at the PHU level, while decisions about the latter were made by the province, which classified PHUs into three groups, with some exceptions.

Regarding behavioral responses, we use the Google COVID-19 Community Mobility Reports, which summarize daily cellphone geo-location data for each province as indices calculated relative to the median value for the same day of the week in the five-week baseline

[7] The provinces differ in the ease of accessibility of their official time series of COVID-19 cases, deaths and test numbers. In some cases, we located and used the hidden json sources feeding the public dashboard charts. In few instances in which data were not available, we used the numbers reported in the daily provincial government announcements. All COVID-19 outcome data sources are referenced and web-linked in Appendix Table C3.

[8] Additional survey data on mask usage is described and used in Section 4.4.

period January 3 to February 6, 2020.[9] In Ontario, these location data are available for each of the 51 first-level administrative divisions (counties, regional municipalities, single-tier municipalities and districts).[10]

3 Empirical method

We follow the approach of CKS (2020), but modify and adapt it to the Canadian context. The empirical strategy uses the panel structure of the outcome, policy and behavioral proxy variables, and includes lags of outcomes as information, following the causal paths suggested by the epidemiological SIR model (Kermack and McKendrick, 1927). Specifically, we estimate the effect of policy interventions on COVID-19 outcomes while controlling for information and behaviour. In contrast to CKS (2020) and Hsiang et al. (2020), who study variation in NPIs across U.S. states or across countries, our identification strategy exploits policy variation at the sub-provincial level (Ontario's PHUs) in addition to cross-province variation, and our data captures both the closing down and gradual re-opening stages of the epidemic.

3.1 Estimation strategy

The main data used in our empirical analysis are summarized below; Section 3.2 describes the variables in detail. Everywhere i denotes province for national analysis, and health region (PHU) for Ontario analysis, and t denotes time measured in days.

1. Outcomes, Y_{it} – growth rate of weekly cases or deaths.

2. Information, I_{it} – lagged outcomes, i.e. past levels or growth rate of cases (or deaths). We also consider a specification that includes the past cases/deaths and case/death growth at the national level as additional information variables.

3. Behavioral responses, B_{it} – Google mobility data capturing changes in people's geo-location relative to a baseline period in January-February.

4. Policy/NPIs, P_{it} – for the national analysis, five policy aggregates by province and date; for the Ontario analysis, two policy variables (mask mandates and regulation on business and gathering) by PHU and date.

[9] The reports are available for download at https://www.google.com/covid19/mobility/.

[10] Each of these divisions is either entirely (in most cases) or predominantly located within a single PHU. In cases where a PHU corresponds to multiple divisions, 2016 Census population counts were used as weights to compute the PHU's mobility index.

5. Controls, W_{it} – province or PHU fixed effects, growth rate of weekly new COVID-19 tests, and a time trend.

To assess and disentangle the impact of NPIs and behavioral responses on COVID-19 outcomes, we estimate the following equation:

$$Y_{it} = \alpha B_{it-l} + \pi P_{it-l} + \mu I_{it} + \delta_Y W_{it} + \varepsilon_{it}^Y \tag{1}$$

where l denotes a time lag measured in days. Equation (1) models the relationship between COVID-19 outcomes, Y_{it}, and lagged behaviour, B_{it-l}, lagged policy measures, P_{it-l} and information (past outcomes), $I_{it} = Y_{it-l}$. For case growth as the outcome, we use $l = 14$. For deaths growth as the outcome, we use $l = 28$.[11] The choice of these lags is discussed in Appendix D.

By including lagged outcomes, our approach allows for possible endogeneity of the policy interventions P_{it}, that is, the introduction or relaxation of NPIs based on information on the level or growth rate of cases or deaths. Also, past cases may be correlated with (lagged) government policies or behaviors that may not be fully captured by the policy and behaviour variables.

In Appendix Table A18, we also report estimates of the following equation:

$$B_{it} = \beta P_{it} + \gamma I_{it} + \delta_B W_{it} + \varepsilon_{it}^B \tag{2}$$

which models the relationship between policies P_{it}, information, I_{it} (weekly levels or growth of cases or deaths) and behaviour, B_{it}. It is assumed that behaviour reacts to the information without a significant lag. We find strong correlation between policy measures and the Google mobility behavioral proxy measure.

Equation (1) captures both the direct effect of policies on outcomes, with the appropriate lag, as well as the potential indirect effect on outcomes from changes in behaviour captured by the changes in geo-location proxy B_{it-l}. In Appendix Tables A19 and A20, we also report estimates of equation (1) without including the behavioral proxy, that is, capturing the total effect of policies on outcomes. Since our estimates of the coefficient α in equation (1) are not significantly different from zero, the results without controlling for the behavioral proxy are very similar to those from estimating equation (1).

[11] Our lag for deaths is one week longer than that used by CKS (2020). The difference is due to additional evidence from the medical literature and the construction of the weekly variables (see Appendix D).

3.2 Variables and descriptive analysis

Outcomes. Our main outcome of interest is the growth rate of weekly new positive COVID-19 cases as defined below.[12] We use weekly outcome data to correct for the strong day-of-the-week effect present in COVID-19 outcome data.[13] Weekly case growth is a metric that can be helpful in assessing trends in the spread of COVID-19, and it is highlighted in the World Health Organization's weekly epidemiological updates (see, for example, World Health Organization (2020)).

Specifically, let C_{it} denote the cumulative case count up to day t and define ΔC_{it} as the weekly COVID-19 cases reported for the 7-day period ending at day t:

$$\Delta C_{it} \equiv C_{it} - C_{it-7}.$$

The weekly case (log) growth rate is then defined as:

$$Y_{it} = \Delta \log(\Delta C_{it}) = \log(\Delta C_{it}) - \log(\Delta C_{it-7}), \tag{3}$$

that is, the week-over-week growth in cases in region i ending on day t.[14] The weekly death growth rate is defined analogously, using cumulative deaths data.

Policy. In the Ontario analysis, we exploit regional variation in the timing of indoor mask mandates staggered over two months in the province's 34 regions ("public health units" or PHUs). Figure 1 displays the gradual introduction of mask mandates across the 34 PHUs in Ontario. The exact implementation dates of the mask mandates are reported in Table C2. Mandatory indoor masks were introduced first in the Wellington-Dufferin-Guelph PHU on June 12 and last in the Northwestern PHU on August 17.[15]

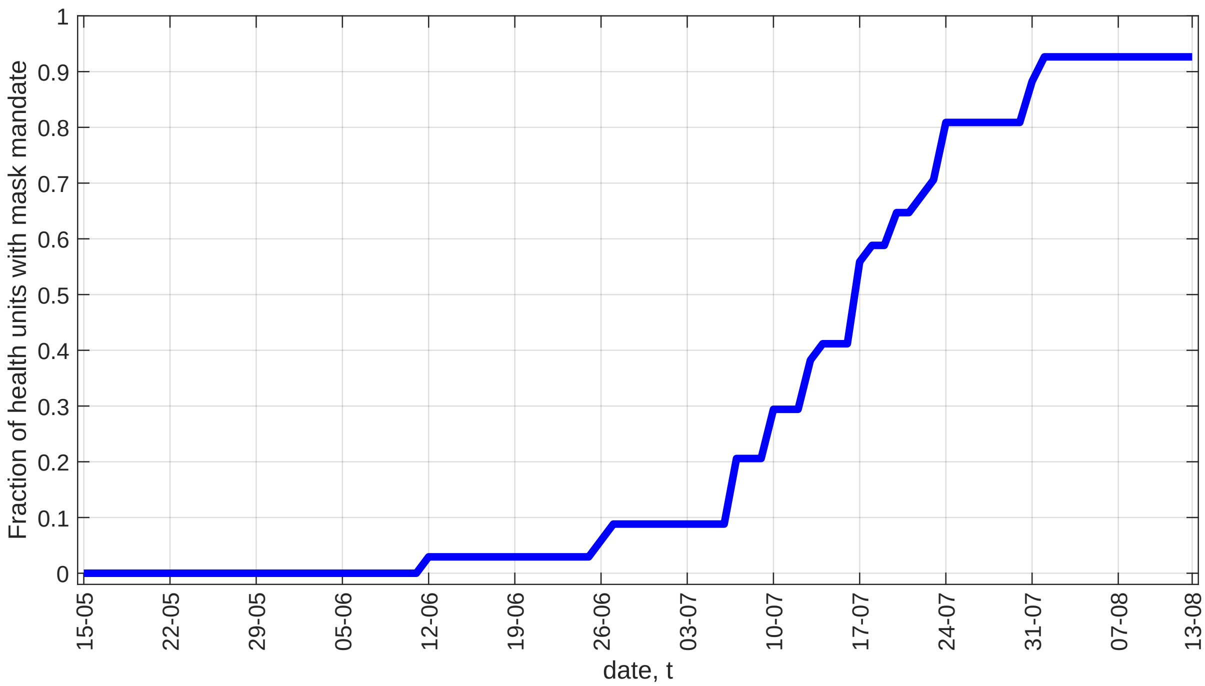
[12] We also report results using the growth rate of deaths as supplemental analysis in Section 4.5.

[13] Figures B9 and B10 in the Appendix respectively display the weekly and daily cases, deaths and tests in each Canadian province over time. There are markedly lower numbers reported on weekends or holidays.

[14] To deal with zero weekly values, which mostly occur in the smaller regions, as in CKS (2020), we replace log(0) with -1. We also check the robustness of our results by adding 1 to all ΔC_{it} observations before taking logs, by replacing log(0) with 0, and by using population weighted least squares; see Tables A5 and A8.

[15] There is no PHU-wide mask mandate in Lambton as of August 31, but its main city, Sarnia, enacted a mask mandate on July 31.

Figure 1: Ontario - mask mandates over time



Notes: There are a total of 34 public health units (PHU) in Ontario. See Table C2 for the exact date of mask mandate implementation in each PHU.

In the province-level analysis, we assign numerical values to each of the 17 policy indicators listed in Table C1 in Appendix C. The values are on the interval [0,1], with 0 meaning no or lowest level of restrictions and 1 meaning maximal restrictions. A policy value between 0 and 1 indicates partial restrictions, either in terms of intensity (see more detail and the definitions in Table C1) or by geographical coverage (in large provinces). The numerical values are assigned at the daily level for each region (PHU or province, respectively for the Ontario and national results), while maintaining comparability across regions.

Many NPIs were implemented at the same time, both relative to each other and/or across regions (especially during the March closing-down period), which causes many of the policy indicators to be highly correlated with each other (see Appendix Table A4). To avoid multi-collinearity issues, we group the 17 policy indicators into 5 policy aggregates via simple averaging: (i) *travel*, which includes international and domestic travel restrictions and self-isolation rules; (ii) *school*, which is an indicator of provincial school closure; (iii) *business/gathering*, which comprises regulations and restrictions on non-essential businesses and retail, personal businesses, restaurants, bars and nightclubs, places of worship, events, gyms and recreation, and limits on gathering; (iv) *long-term care (LTC)*, which includes NPIs governing the operation of long-term care homes (visitor rules and whether staff are required to work on a single site) and (v) *mask* which takes value 1 if an indoor mask mandate has been introduced, 0 if not, or value between 0 and 1 if only part of a province has enacted such policy.[16]

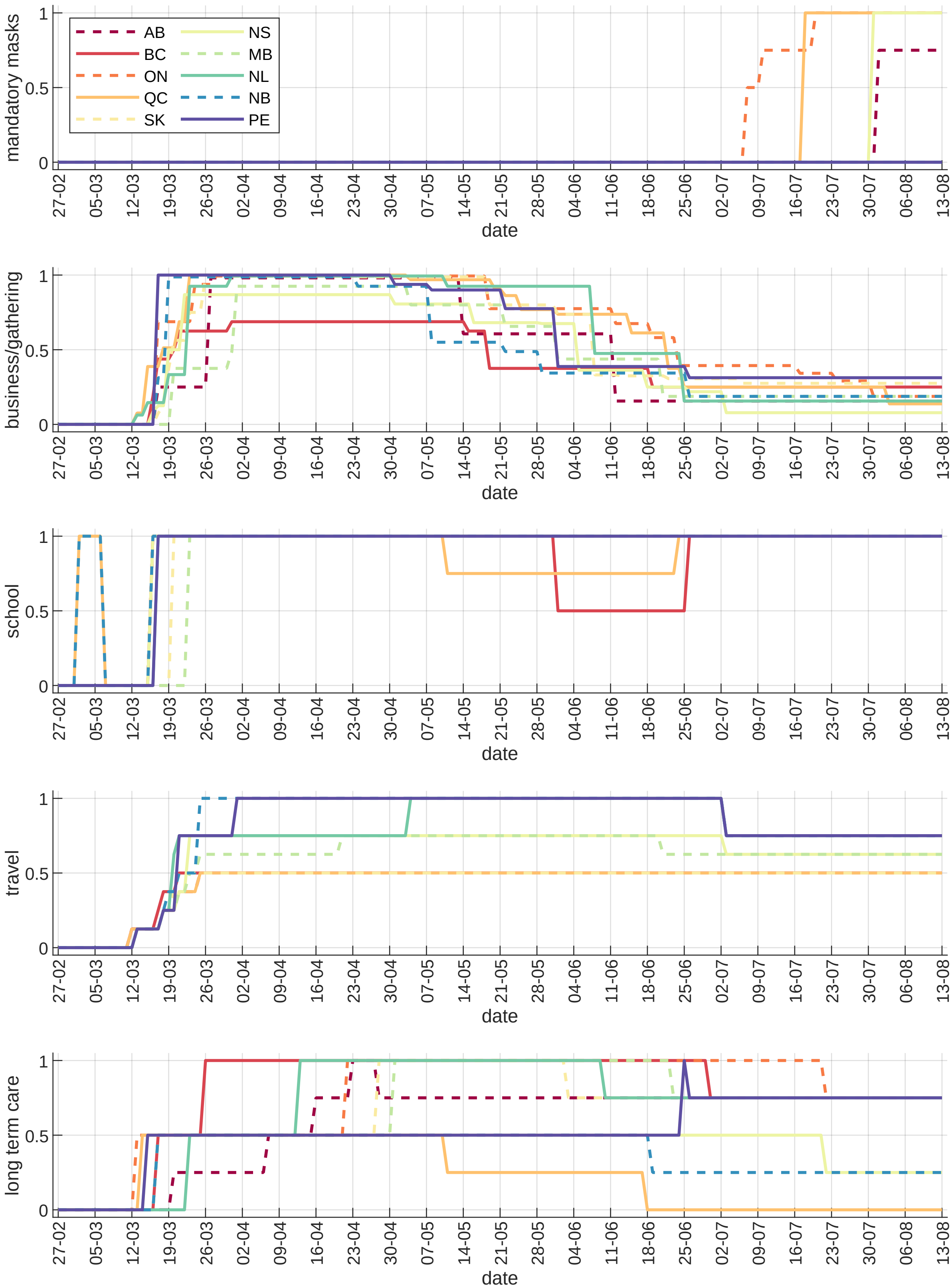
The five policy aggregates are constructed at the daily level and capture both the closing-down period (an increase in the numerical value from 0 toward 1) and the re-opening period (decrease in the numerical value toward zero). In comparison, the policy indicators compiled by Raifman (2020) for the USA used in CKS (2020) are binary "on (1)"/"off (0)" variables.[17] For consistency with the weekly outcome and information variables and the empirical model timing, we construct the policy aggregates P_{it}^{j} used in the regressions (where j denotes policy type) by taking a weekly moving average of the raw policy data, from date $t-6$ to date t.

Figure 2 plots the values of the 5 policy aggregates over time for each of the 10 provinces. Travel restrictions, school closures (including Spring and Summer breaks) and business closures were implemented in a relatively short period in the middle of March. There is some variation in the travel policy aggregate since some Canadian provinces (the Atlantic provinces and Manitoba) implemented inter-provincial domestic travel or self-isolation restrictions in addition to the federal regulations regarding international travel. Restrictions on long-term care facilities were introduced more gradually. In the re-opening period (May-August), there is also more policy intensity variation across the provinces, especially in the business and gatherings category, as the different provinces implemented their own re-opening plans and strategies. Mask mandates were first introduced in Ontario starting from June in some smaller PHUs and early July in the most populous PHUs such as Toronto, Ottawa and Peel (see Appendix Table C2). In Quebec, indoor masks were mandated province-wide on July 18. Nova Scotia and Alberta's two main cities implemented mask mandates on July 31 and August 1, respectively.

[16]We do not use provincial declarations of emergency in our analysis as they are mostly legal tools enabling other restrictions rather than restrictions *per se*.

[17]The daily numerical values for each of the 17 basic policy indicators and the 5 policy aggregates for each province and date are available on the project's Github repository.

Figure 2: Policy aggregates - Canada



Notes: The figure plots the numerical values of the 5 policy aggregates (Mask, Business /gathering, School, Travel and Long-term care, LTC) over time, for each of the 10 provinces. The mask policy values for ON reflect the gradual adoption of mandates and the respective PHUs population sizes.

There are two empirical challenges specific to our Canadian context and data. The first challenge is the presence of small provinces and sub-regions with very few COVID-19 cases or deaths. In Section 4.3, we perform a number of robustness checks using different ways of handling the observations with very few cases (in particular zero cases). The second data limitation is that there are only 10 provinces in Canada and 34 public health units in Ontario, unlike the 51 U.S. jurisdictions in CKS (2020). To account for the resulting small number of clusters in the estimation, we compute and report wild bootstrap standard errors and p-values, as proposed by Cameron et al. (2008).[18] On the flip side, our data has the advantage of a longer time horizon (March to August) and non-binary, more detailed policy variables compared to Raifman et al. (2020).

Behaviour proxy. We follow CKS (2020) and other authors in interpreting the location change indices from the Google Community Mobility reports as proxies for changes in people's behaviour during the pandemic, keeping in mind that location is only one aspect of behaviour relevant to COVID-19. The general pattern in the data (see Figure B3) shows sharply reduced frequency of recorded geo-locations in shops, workplaces and transit early in the pandemic (March), with a subsequent gradual increase back toward the baseline (except for transit), and a flattening out in July and August.

Several of the six location indicators (retail, grocery and pharmacy, workplaces, transit, parks and residential) are highly correlated with each other (see Tables A1 and A2) and/or contain many missing observations for the smaller provinces. To address these data limitations and the possible impact of collinearity on the estimation results, we use as proxy for behavioral changes the simple average of the following three mobility indicators: "retail", "grocery and pharmacy" and "workplaces". To be consistent with the weekly outcome variables and to mitigate day-of-week behavioural variation, we construct the Behaviour proxy B_{it} by taking a weekly moving average of the $\frac{1}{3}$ (retail + grocery and pharmacy + workplaces) data, from date $t-6$ to date t.[19,20] As a result, our empirical analysis uses weekly totals (for cases, tests and deaths) or weekly moving averages (for policies and the behaviour proxy) of all variables recorded on daily basis.[21]

[18] Alternative methods for computing the standard errors are explored in Section 4.3.

[19] We drop the "transit", "parks", and "residential" location indicators because, respectively, 10.6%, 13.7%, and 2.8% of the observations are missing in the provincial data, and 20.7%, 52.1%, and 11.1% are missing in the Ontario data. The "transit" and "residential" variables are also highly correlated with the three indicators we include in our aggregate behaviour proxy B_{it}. Furthermore, the "parks" indicator does not have clear implication for COVID-19 outcomes.

[20] In the Ontario analysis, 1.4% of the B_{it} values are imputed via linear interpolation.

[21] In estimation equation (1), we take moving average from date $t-14$ to date $t-20$ for policies and behaviour when the outcome is weekly case growth, and from date $t-28$ to date $t-34$ if the outcome is

Tables A3 and A4 display the correlation between our behaviour proxy B_{it} and the five NPI policy aggregates P_{it}^{j}. Importantly, the behaviour proxy and mask mandate variables are not highly correlated, suggesting that the effect of mask mandates on COVID-19 outcomes should be independent of location behaviour changes.

Information. We use the weekly cases and case growth variables defined above, ΔC_{it} and Y_{it}, to construct the information variables I_{it} in equation (1). Specifically, we use as information the lagged value of the weekly case growth rate Y_{it-l} $(= \Delta \log(\Delta C_{it-l})$ and the log of past weekly cases, $\log(\Delta C_{it-l})$. We also use the lagged provincial (Ontario analysis) or national (Canada analysis) case growth rate and log of weekly cases as additional information variables in some specifications. A two-week information lag $l = 14$ is used in the baseline results. In the supplementary regressions using the death growth rate as the outcome, we use information on past deaths and a four-week lag (see Section 4.5).

Control variables. In all regressions, we control for region fixed effects (PHU or province) and the weekly COVID-19 tests growth rate $\Delta \log(\Delta T_{it})$, where T_{it} denotes cumulative tests in region i until date t and ΔT_{it} is defined analogously to ΔC_{it} above. We include a time trend: our baseline uses a cubic polynomial in days, but we also report results with no time trend and with week fixed effects. Robustness checks also include news or weather variables as controls (see Section 4.3).

Time period. We use the period May 15 to August 13 for the analysis with Ontario PHU level data and the period March 11 to August 13 for the national analysis with provincial data. The end date reflects data availability at the time of empirical analysis and writing. The start date for the Ontario sample (May 15) is approximately two weeks after the last restrictive measures were implemented and four weeks before the first mask mandate was introduced in Ontario. Robustness checks with different initial dates (May 1, June 1 and June 15) are reported in Section 4.3, with our results remaining stable. The initial date for the national sample (March 11) was chosen as the first date on which each province reported at least one COVID-19 test (so that cases could be potentially reported). Again, alternative initial dates are explored in Section 4.3.

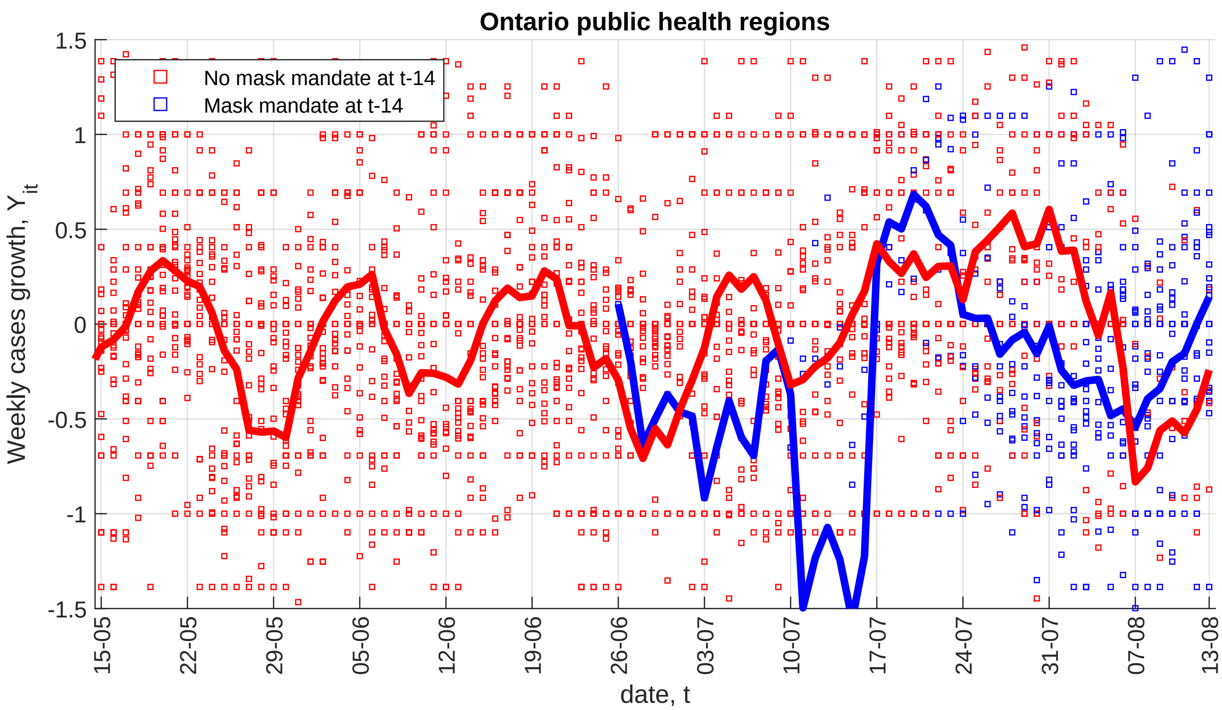
deaths growth. Alternative lags are explored in Section 4.3.

4 Results

4.1 Mask mandates in Ontario public health regions

We start with a simple graphical illustration of the effect of mask mandates on COVID-19 cases growth. Figure 3 displays the average log case growth, $Y_{it} = \Delta \log(\Delta C_{it})$ in Ontario PHUs with or without mask mandates. It shows that, on average, the PHUs with a mask mandate two weeks prior have lower case growth than the PHUs without a mask mandate two weeks prior.

Figure 3: Ontario - mask mandates and weekly case growth



Notes: The figure plots the average log weekly case growth $\Delta\log(\Delta C)$ in the PHUs with mask mandate (blue) vs. without (red) mask mandate 14 days prior.

Table 1 shows the estimates of equation (1), in which we control for other policies, behaviour and information, as explained in Section 3.1.[22] We report wild bootstrap p-values clustered at the PHU level to account for the small number of clusters.[23] The odd-numbered

[22]Mask mandates and regulations on business and gatherings vary at the PHU level. Long-term care policy changed only province-wide. The other policies (schooling and travel) do not vary during the sample period and hence are omitted from the regressions with Ontario PHU data.

[23]Table A6 in the Appendix reports alternative standard error specifications: regular clustering at the PHU level (Stata command "cluster"), wild bootstrap standard errors clustered at the PHU level, and wild

columns in Table 1 use lagged cases and lagged cases growth at the PHU level as information; the even-numbered columns also include lagged cases and lagged case growth at the province level as additional information variables. In the tables, *Variable*_14 indicates a 14-day lag of *Variable*.

We present estimates of equation (1) from three specifications that handle possible time effects differently. Columns (1) and (2) in Table 1 are the most basic specifications, without including a time trend. The estimates in columns (1) and (2) suggest that, controlling for behavioural changes, mandatory indoor face masks reduce the growth rate of infections by 29–32 log points ($p < 0.05$), which is equivalent to a 25–28% reduction in weekly cases.[24]

In order to control for potential province-wide factors affecting the spread of COVID-19 such as income support policies or adaptation to the pandemic over time (so-called COVID fatigue), we also estimate (1) with a cubic time trend in days from the beginning of the sample, in columns (3) and (4) of Table 1, and with week fixed effects, in columns (5) and (6). Columns (3)-(6) show that our estimates of the mask mandate policy remain robust to the inclusion of a cubic time trend or week fixed effects. The results indicate that, depending on the specification, mask mandates are associated with a reduction of up to 38 log points in weekly case growth or, equivalently, a 31% reduction in weekly cases. The magnitude of the mask policy estimate is not very sensitive to whether lagged province-level data are included as additional information.

The results in Table 1 suggest that indoor mask mandates can be a powerful preventative measure in the COVID-19 context. Our estimates of the mask mandate impact across Ontario's PHUs are equivalent to a 25–31% reduction in weekly cases. This estimate is larger than the 9–10% reduction estimated by CKS (2020) for the U.S. One possible explanation is that Ontario's mask policy is more comprehensive: we evaluate the effect of *universal* indoor mask-wearing for the public rather than the effect of mask wearing for *employees only* in CKS (2020). Differences in the compliance rate may also contribute to this difference; we discuss this potential channel in Section 4.4.

The results in Table 1 also show a statistically significant negative association between information (log of past cases, log(ΔC)_14) and current weekly case growth ($p < 0.01$ in all specifications), indicating that a higher level of cases two weeks prior is correlated with lower current case growth. While B_{it} allows for behavioural responses to information, the negative estimate on log(ΔC)_14 in Table 1 suggests that our location-based proxy does not capture

bootstrap standard errors clustered by both PHU and date. Our results are robust to alternative ways of calculating standard errors.

[24]Using equation (3), a coefficient of x translates into a $1-\exp(x)$ reduction in weekly cases $\Delta C_{it}/\Delta C_{it-7}$.

Table 1: Main Results - Ontario public health regions

	Outcome: weekly case growth Y_{it}=$\Delta\log(\Delta C_{it})$					
	(1)	(2)	(3)	(4)	(5)	(6)
	no time trend		cubic time trend		week fixed effects	
Mask_14	-0.291 **	-0.323 **	-0.366 **	-0.376 ***	-0.319 **	-0.327 **
	[0.017]	[0.016]	[0.010]	[0.008]	[0.021]	[0.019]
Business/gathering_14	-0.625	-0.457	-0.137	0.279	-0.098	0.054
	[0.209]	[0.473]	[0.877]	[0.689]	[0.890]	[0.935]
Long-term care_14	0.643	0.544	0.747	-0.097	-1.044	-1.997
	[0.463]	[0.549]	[0.677]	[0.930]	[0.388]	[0.102]
Behaviour proxy_14	-0.020	-0.016	-0.018	-0.018	-0.016	-0.014
	[0.160]	[0.215]	[0.266]	[0.272]	[0.302]	[0.352]
Δlog(ΔC)_14	0.030	0.029	0.024	0.028	0.013	0.012
	[0.614]	[0.649]	[0.692]	[0.665]	[0.817]	[0.834]
log(ΔC)_14	-0.214 ***	-0.214 ***	-0.203 ***	-0.209 ***	-0.199 ***	-0.201 ***
	[0.000]	[0.000]	[0.001]	[0.001]	[0.001]	[0.001]
Δlog(ΔPC)_14		0.287		0.184		0.543 **
		[0.307]		[0.566]		[0.046]
log(ΔPC)_14		-0.028		0.528		0.112
		[0.907]		[0.124]		[0.744]
Δlog(ΔT)	-0.313 *	-0.409 *	-0.260	-0.382	-0.230	-0.480
	[0.087]	[0.058]	[0.287]	[0.125]	[0.492]	[0.138]
R-squared	0.046	0.050	0.051	0.058	0.091	0.094
N	3,094	3,094	3,094	3,094	3,094	3,094
public health unit FE	X	X	X	X	X	X
cubic time trend (days)			X	X		
week fixed effects					X	X

Notes: The sample time period is May 15 to August 13, 2020. P-values from wild bootstrap (cgmwildboot) standard errors clustered by public health unit (PHU) with 5000 repetitions are reported in the square brackets. Mask_14, Business/gathering_14, Behaviour_14, Δlog(ΔC)_14, and log(ΔC)_14 are measured at the PHU level, while Long-term care_14, Δlog(ΔPC)_14, log(ΔPC)_14, and Δlog(ΔT) are measured at the province level. PC denotes provincial total cases. ***, ** and * denote 10%, 5% and 1% significance level respectively. Missing values (1.3% of all observations) for Behaviour proxy_14 are imputed via linear interpolation.

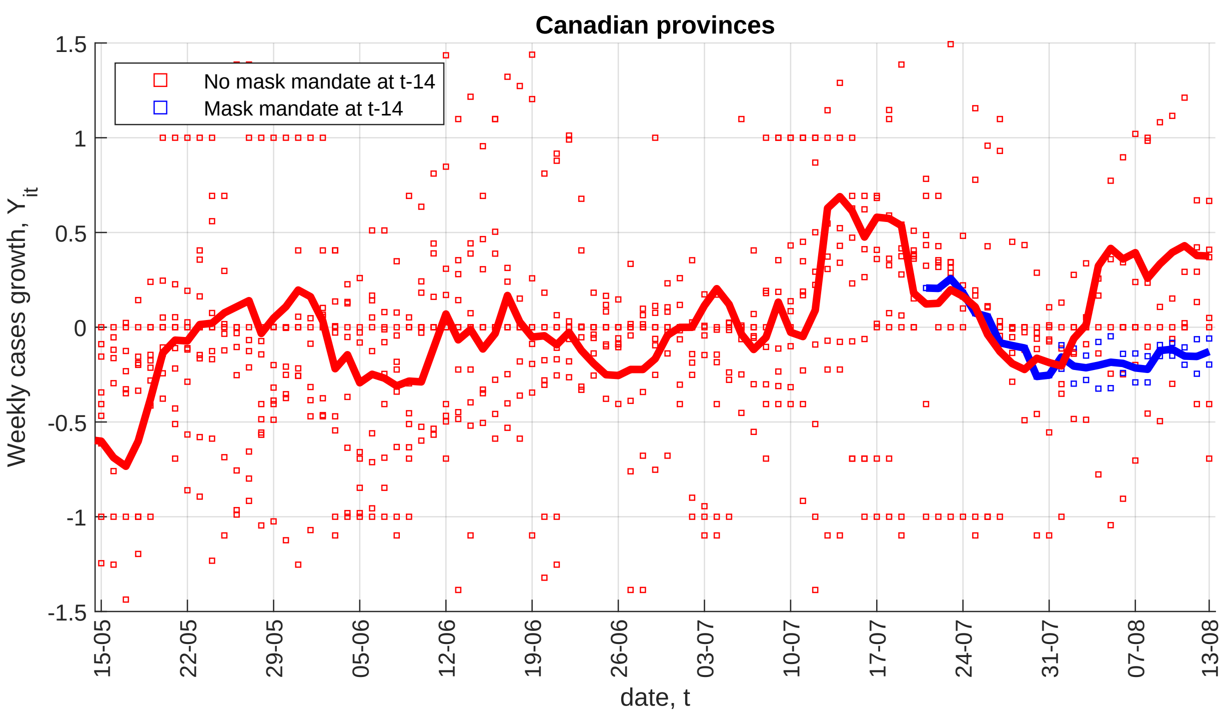
important aspects of behaviour, such as frequent hand-washing or physical distancing. In fact, our coefficient estimate on the behavioral proxy B_{it} is very close to zero (both in Table

1 and in Section 4.2's province-level results), unlike in CKS (2020).[25] In Appendix Table A18, we find strong contemporaneous correlations between the policy measures, log cases, and the Google mobility behavioral proxy from estimating equation (2). This suggests that the information (lagged cases) and the lagged policy variables included in equation (1) may absorb lagged behavioral responses proxied by B_{it-l} or other latent behavioral changes not captured by B_{it-l}.

4.2 Province-level results

We next evaluate the impact of NPIs on COVID-19 cases growth in Canada as a whole by exploiting variation in the timing of policies across the 10 provinces. Here, we examine NPIs for which there is no variation across Ontario's PHUs (i.e., schooling, travel, and LTC) in addition to mask mandates. Also, provincial data contain variation in the timing of policy changes in both the closing and re-opening phases, allowing us to study both the imposition and relaxation of restrictions.

Figure 4: Canada - mask mandates and weekly case growth



Notes: The figure plots the average weekly case growth $\Delta\log(\Delta C)$ in the provinces with mask mandate (blue) vs. without mask mandate (red) 14 days prior.

[25] We also tried including each location change measure separately and the results are similar (not shown).

As in the Ontario analysis, we begin with a graphical illustration of mask mandates and COVID-19 case growth across Canadian provinces, in the period March 11 to August 13, 2020. Figure 4 plots the average log weekly case growth in the provinces with vs. without mask mandates. While mask mandates are implemented relatively late in our sample period, average case growth in the provinces with a mask mandate (Ontario and Quebec) diverged from the average case growth in the provinces without a mandate begin roughly four weeks after the mandates are imposed.[26]

Table 2 displays the estimates of equation (1) for weekly case growth, along with wild bootstrap p-values, clustered at the province level (see Table A9 for other methods of computing the standard errors). The odd-numbered columns use lagged cases and lagged case growth at the provincial level as information while the even-numbered columns include in addition lagged cases and case growth at the national level as additional information variables.

As in the Ontario analysis, we present in Table 2 estimates from three specifications: no time trend (columns (1)-(2)), including cubic time trend in days (columns (3)-(4)) and including week fixed effects (columns (5)-(6)). The most robust result is the estimated effect of mask mandates: they are associated with a large reduction in weekly case growth of 45 to 62 log points, which is equivalent to a 36 to 46% reduction in weekly cases across the different specifications. The estimates are statistically significantly different from zero in all cases, with a p-value of less than 0.001 in columns (1)-(4). It is reassuring that these results regarding mask mandates are consistent with the Ontario analysis in the previous section.

Table 2 further shows that restrictions on businesses and gatherings are associated with a reduction in the weekly case growth of 65 to 85 log points or, vice versa, that relaxing business/gathering restrictions is associated with higher case growth. The estimate is equivalent to a 48 to 57% decrease in weekly cases in our sample period. The business/gathering estimates are, however, more noisy than our estimates for mask mandates and do not retain statistical significance in the specifications with week fixed effects ($p = 0.15$ and 0.14). Tables A8 and A15 further suggest that the results on business and gathering NPIs are driven by the smaller provinces and the re-opening period (May to August). Still, these results suggest that lowered restrictions and the associated increase in business/workplace activity or gatherings can be an important offsetting factor for the estimated effect of mask mandates on COVID-19 case growth, both in our sample and in the future.

We also find that school closures (the School_14 variable in Table 2) can be negatively

[26] Figure 4 assumes a July 7 mask mandate implementation date for Ontario (when its most populous PHU, Toronto, adopted a mask mandate, along with Ottawa), and July 18 for Quebec (province-wide mandate).

Table 2: Main Results – Canada

	Outcome: weekly case growth Y_{it}=$\Delta\log(\Delta C_{it})$					
	(1)	(2)	(3)	(4)	(5)	(6)
	no time trend		cubic time trend		week fixed effects	
Mask_14	-0.446 ***	-0.484 ***	-0.618 ***	-0.613 ***	-0.581 **	-0.567 **
	[0.000]	[0.000]	[0.000]	[0.000]	[0.030]	[0.026]
Business/gathering_14	-0.654 **	-0.827 **	-0.835 **	-0.846 **	-0.648	-0.694
	[0.018]	[0.019]	[0.031]	[0.033]	[0.146]	[0.137]
School_14	-0.336	-0.480	-0.425 **	-0.433 **	-0.261	-0.347
	[0.352]	[0.196]	[0.015]	[0.019]	[0.235]	[0.130]
Travel_14	-0.585	-0.772	-0.375	-0.412	-0.396	-0.553
	[0.146]	[0.118]	[0.613]	[0.636]	[0.695]	[0.559]
Long-term care_14	-0.052	-0.119	0.023	0.032	0.063	0.056
	[0.824]	[0.715]	[0.958]	[0.920]	[0.889]	[0.898]
Behaviour proxy_14	-0.009	-0.008	-0.001	0.000	-0.003	0.001
	[0.257]	[0.350]	[0.880]	[0.972]	[0.858]	[0.935]
$\Delta\log(\Delta C)$_14	-0.061	-0.062	-0.078 *	-0.072	-0.055	-0.054
	[0.177]	[0.262]	[0.090]	[0.198]	[0.449]	[0.459]
$\log(\Delta C)$_14	-0.223 ***	-0.244 ***	-0.227 **	-0.227 *	-0.224	-0.232
	[0.000]	[0.003]	[0.019]	[0.090]	[0.102]	[0.113]
$\Delta\log(\Delta NC)$_14		0.015		-0.107		-0.050
		[0.895]		[0.631]		[0.807]
$\log(\Delta NC)$_14		0.141		0.055		0.302 **
		[0.326]		[0.825]		[0.048]
$\Delta\log(\Delta T)$	0.112	0.166 *	0.172 **	0.169 *	0.158	0.166 *
	[0.170]	[0.074]	[0.043]	[0.056]	[0.110]	[0.073]
R-squared	0.406	0.410	0.414	0.414	0.430	0.433
N	1,560	1,560	1,560	1,560	1,560	1,560
province fixed effects	X	X	X	X	X	X
cubic time trend (days)			X	X		
week fixed effects					X	X

Notes: The time period is March 11 to August 13, 2020. P-values from wild bootstrap (cgmwildboot) standard errors clustered by province with 5000 repetitions are reported in the square brackets. ***, ** and * denote 10%, 5% and 1% significance level respectively. NC denotes national total cases.

associated with case growth. However, the estimates are statistically significant from zero only in the specifications with cubic time trend (columns (3) and (4)). As seen in Figure

2, provincial school closures occurred in a very short time interval during March, so we may lack statistical power to separately identify its effect from other NPIs (especially the travel-related). Hence, we interpret this result with caution.

As in Table 1, the level of past cases, $\log(\Delta C)$, is negatively and statistically significantly associated with current weekly case growth in columns (1)-(4).

Since the specification with cubic time trend in Tables 1 and 2 allows for possible non-monotonic aggregate time trends in case growth in a parsimonious way, we choose it as our baseline specification with which to perform robustness checks in the next section. Robustness checks with the other specifications are available upon request.

4.3 Robustness

Policy collinearity

A possible concern about our data for the national analysis is that some NPIs (e.g. international travel restrictions or closing of schools) were implemented within a very short time interval.[27] Thus, we may lack enough regional variation to distinguish and identify the separate effect of each policy.[28] Collinearity could also affect the standard errors and the signs of the estimated coefficients.

To check robustness with respect to potential collinearity in the NPI policies, Tables A7 and A10 report estimates from our baseline specification, omitting one policy at a time, for Ontario and Canada respectively. First, it is reassuring that the mask mandate estimates are hardly affected by omitting any of the other policies. This is expected since mask mandates were imposed during a period where other NPIs changed little (see Figure 2). Similarly, the effects of business/gathering regulations and school closures in Table A10 are not sensitive to omitting other policies one at a time, which suggests that there is sufficient statistical power and variation to identify them in the national analysis.

Treatment of zero weekly cases

Another concern for our empirical strategy is that the usual formula for our dependent variable, $\Delta \log(\Delta C_{it})$, cannot be applied when the weekly case total ΔC_{it} is zero. We follow CKS (2020) and replace ln(0) with -1 in our baseline specifications in Tables 1 and 2. We now check the robustness of our estimates to alternative treatments of zero weekly cases.

For easier comparison, the first two columns in Table A5 repeat columns (3) and (4)

[27] For example, Table A4 shows a correlation of 0.61 between the Travel and School policy aggregates.

[28] Aggregating the 17 basic policy indicators into five groups mitigates this issue. Here, we test whether any remaining collinearity poses a problem.

from Table 1 for Ontario.[29] Our main results on mask mandates across Ontario PHUs are robust to replacing log(0) with 0 and to adding 1 to all ΔC_{it} observations before taking logs, as shown in columns (3)-(6) of Table A5. Another way to mitigate the issue of PHUs with very few cases is to estimate a weighted least squares regression where PHUs are weighted by population. Columns (7) and (8) in Table A5 show that the resulting mask estimate has a slightly smaller magnitude and, due to the reduced effective sample size, weaker statistical significance.

Similarly, Table A8 shows that our province-level estimates, in particular for mask mandates, are also robust to the same manipulations as above.[30] In columns (9) and (10) of Table A8, we restrict the sample to only the largest 4 provinces (British Columbia, Ontario, Quebec and Alberta), which have only 0.3% (2 out of 624) zero observation cases. Again, the estimated mask effects are little changed.

Alternative dates

Figure B4 shows that our estimates and confidence intervals for the effect of mask mandates in the Ontario baseline regressions do not vary much by the initial date of the sample. Similarly, Figure B5 shows that, in the national analysis, our results about mask mandates and business/gathering restrictions are also robust to alternative sample start dates.

Alternative lags

We explore alternative time lags, either shorter or longer in duration, centered around the baseline value of 14 days. Figure B6 (with Ontario data) and Figure B7 (with province-level data) plot the estimates and confidence intervals from the baseline regressions and show that our mask effect estimates remain fairly consistent for different lags.

Omitted variables

Our behaviour proxy variable (Google geo-location trends) likely misses some aspects of behaviour relevant for COVID-19 transmission. One factor that may meaningfully impact behaviour is weather. For example, good weather could entice more people to spend time outside, lowering the chance of viral transmission. Columns (3) and (4) in Table A11 report national estimates with lagged weather variables (daily maximum and minimum temperatures and precipitation for the largest city in each province[31]) as additional regressors. Our NPI estimates, in particular mask mandates, are little changed from the baseline results in columns (1) and (2).

[29] 535 out of 3,094 observations (17%) had to be replaced.

[30] 230 out of 1,560 observations (15%) had to be replaced.

[31] Vancouver, BC; Calgary, AB; Saskatoon, SK; Winnipeg, MB; Toronto, ON; Montreal, QC; Moncton, NB; Halifax, NS; Charlottetown, PE; and St. John's, NL.

Another possible concern is that our information variables, lagged cases and lagged case growth, may not fully capture the information based on which people react or adjust their behaviour, possibly affecting the observed weekly case growth. Columns (5) and (6) in Table A11 add a national-level "news" variable to the baseline specification. The news variable is defined as the number of daily search results from a news aggregator website (*Proquest Canadian Newsstream*) for the terms "coronavirus" or "COVID-19" (see Appendix C for more details). In column (6), the lagged news variable approaches the 10% significance level ($p = 0.103$). Our estimates on masks and business/gathering remain very close to those in the baseline.

4.4 Self-reported mask usage

The effectiveness of any NPI or public policy crucially depends on whether it affects behaviour. In this section, we use self-reported data on mask usage to examine whether mask mandates indeed increase mask use in Canada ("first-stage" analysis).

We use data from the YouGov COVID-19 Public Monitor, which includes multiple waves of public opinion surveys fielded regularly since early April in many countries.[32] Here, we focus on inter-provincial comparison within Canada. Our variable of interest is based on responses to the question "Thinking about the last 7 days, how often have you worn a face mask outside your home (e.g. when on public transport, going to a supermarket, going to a main road)?" The answer choices are "Always", "Frequently", "Sometimes", "Rarely", and "Not at all". We create a binary variable taking value 1 if the response is "Always" and 0 otherwise, as well as another variable taking value of 1 if the respondent answered either "Always" or "Frequently" and 0 otherwise.

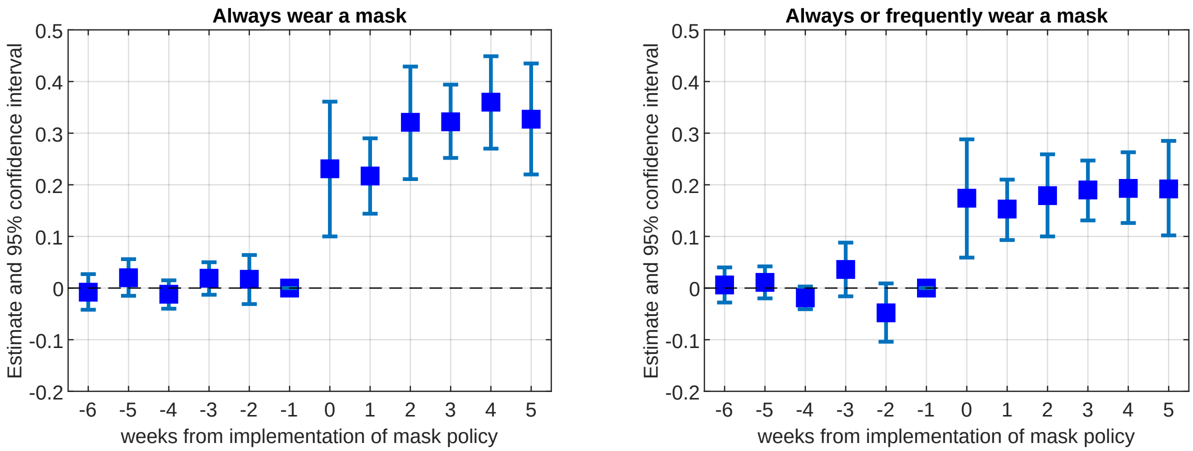
We begin with a simple illustration of self-reported mask usage in Canada from April to August 2020. Figure B2 plots the average self-reported mask usage (the response "Always") in the provinces with and without mask mandates.[33] The figure clearly shows that self-reported mask usage is higher, by up to 50 percentage points, in the provinces with a mask mandate than in the provinces without mask mandates. Since Figure B2 does not account for compositional changes in the data, we formally estimate equation (2), using self-reported mask usage as the behavioral outcome.[34]

[32] The YouGov data can be accessed at: https://yougov.co.uk/covid-19.

[33] As on Figure 4, we use July 7 as the mask mandate implementation date in Ontario.

[34] Since mask usage is reported only for specific dates within each survey wave, we use our mask policy variable daily values for these same dates instead of the weekly moving average.

Figure 5: Event Study of Self-reported Mask Usage – Canada



Notes: The data source is YouGov. The outcome is a binary variable taking value 1 if the respondent respectively answered "Always" (in the left panel) or "Always" or "Frequently" (in the right panel) to "Thinking about the last 7 days, how often have you worn a face mask outside your home?" The figure plots the estimates from a version of equation (2) where the mask policy variable is replaced by the interaction of the variables corresponding to being in the treatment group (imposed mask mandate) and a series of dummies for each week, ranging from 6 weeks before the mask mandate to 6 weeks after ($T = –6$ to $+5$, where $T = 0$ is the mandate implementation date). The reference point is 1 week before the implementation ($T = –1$). Wild bootstrap (cgmwildboot) standard errors clustered by province with 5000 repetitions are used to construct the confidence intervals. Sample weights are used.

Figure 5 shows a graphical event study analysis on mask mandates and changes in mask usage. The event study approach is appropriate for the mask usage outcome variable, since the policy impact is expected to be immediate, unlike the other outcomes we study, for which any impact is expected to occur with a lag and we use weekly totals or moving averages. We replace the mask policy variable in equation (2) by the interaction of variables corresponding to being in the treatment group (i.e. under a mask mandate), and a series of dummies for each week, ranging from 6 weeks before the mask mandate to 5 weeks after the mask mandate ($T = –6$ to $+5$, where $T = 0$ is the implementation date of the mask mandate). The reference point is one week before the implementation of the mask mandate ($T = –1$), and we use the same y-axis scale on both panels.

The left and right panels of Figure 5 present the results from the event study analysis for the "Always" and "Always" or "Frequently" mask usage answers, respectively. We make several observations. First, neither panel shows a pre-trend – the estimates are close to zero before the mask mandates. This addresses the potential concern that provinces that implemented mask mandates may have had a different trend in mask usage than provinces that did not. Second, the effect of mask mandates on mask usage is immediate: an increase of roughly 20 percentage points as soon as the mask policy is implemented at ($T = 0$). Third, the effect appears persistent rather than transitory, since mask usage after $T = 0$ does not revert to its level before $T = 0$.

Table 3: Self-reported mask usage – Canada

	Outcome: "Always wear mask"					
	(1)	(2)	(3)	(4)	(5)	(6)
	no time trend		cubic time trend		week fixed effects	
Mask	0.404 ***	0.396 ***	0.304 ***	0.315 ***	0.310 ***	0.310 ***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Δlog(ΔC)	-0.017	-0.006	-0.008	-0.006	-0.004	-0.008
	[0.663]	[0.611]	[0.524]	[0.595]	[0.656]	[0.464]
log(ΔC)	-0.025	0.015 **	0.004	0.006	0.006	0.007
	[0.127]	[0.025]	[0.662]	[0.544]	[0.504]	[0.502]
Δlog(ΔNC)		-0.106 *		-0.023		0.191
		[0.054]		[0.324]		[0.108]
log(ΔNC)		-0.089 ***		-0.028		-0.068
		[0.000]		[0.669]		[0.582]
R-squared	0.157	0.169	0.172	0.172	0.173	0.174
N	8,859	8,859	8,859	8,859	8,859	8,859
individual characteristics	X	X	X	X	X	X
province fixed effects	X	X	X	X	X	X
cubic time trend (days)			X	X		
week fixed effects					X	X
† average mask usage rate without mask mandate = 0.298						

Notes: The time period is April 2 to August 13, 2020. P-values from wild bootstrap (cgmwildboot) standard errors clustered by province with 5000 repetitions are reported in the square brackets. NC denotes national total cases. The data source is YouGov. The outcome is a dummy which takes value 1 if the respondent answered "Always" to the survey question "Thinking about the last 7 days, how often have you worn a face mask outside your home?" Sample weights are used. Individual characteristics include a gender dummy, age dummy (in years), dummies for each household size, dummies for each number of children, and dummies for each employment status. ***, ** and * denote 10%, 5% and 1% significance level respectively.

Table 3 displays the estimates on self-reported mask usage (answer "Always") in equation (2) along with wild bootstrap p-values clustered at the province level. The odd-numbered columns use lagged cases and lagged case growth at the provincial level as information while the even-numbered columns include in addition lagged cases and case growth at the national level as additional information variables. As in Table 1 and Table 2, we present estimates without time trend, including cubic time trend (in days), and including week fixed effects. Our preferred specification with cubic time trend, column (4) of Table 3, shows that mask mandates are associated with 31.5 percentage point increase in self-reported mask usage ($p < 0.001$), from a base of self-reported mask usage without mask mandate of 29.8%.[35,36]

These "first-stage" results show that mask mandates exhibit significant compliance in Canada and establish a basis for the significant impact of mask mandates on the spread of COVID-19 that we find. That said, given that mask mandates do not change everyone's behaviour, our estimates in Tables 1 and 2 represent intent-to-treat effects. The full effect of the entire population shifting from not wearing to wearing masks is likely significantly larger.[37]

There is a heated debate on whether community use of masks may create a false sense of security that reduces adherence to other preventive measures. We also investigate this question using YouGov survey data. As Tables A13 and A14 indicate, we find no evidence that mask mandates in Canada have had an offsetting effect on other preventive measures such as hand washing, using sanitizer, avoiding gatherings, and avoiding touching objects in public during the period we study. On the contrary, mask mandates may slightly increase social distancing in one out of the eight precaution categories (avoiding crowded areas) ($p < 0.10$).[38]

4.5 Counterfactuals

We evaluate several counterfactuals corresponding to replacing the actual mask policy in a province or Canada-wide with a counterfactual policy, including absence of mask mandate.

Letting t_0 be the implementation date of a counterfactual policy, we set the counterfactual weekly case count, ΔC_{it}^c, equal to ΔC_{it} for all $t < t_0$. For each date $t \geq t_0$, using the definition of Y_{it} from (3), we then compute the counterfactual weekly cases, ΔC_{it}^c and the counterfactual

[35] Similarly, in Table A12, column (4) shows that "Always" or "Frequent" mask usage increases by 21.5 percentage points. The finding that the increase in mask usage among the "Always" respondents is larger than among the "Always" or "Frequent" respondents is consistent with some people switching from wearing masks "frequently" to "always."

[36] Hatzius et al. (2020) document that state mask mandates in the US increased mask usage roughly by 25 percentage points in 30 days. The compliance with mask mandates may differ across countries or regions based on social norms, peer effects, political reasons or the consequences of noncompliance (e.g., fines).

[37] If we take the increase of about 30 percentage points in reported mask usage induced by mask mandates at face value, the full effect of mask wearing (treatment-on-the-treated effect) would be roughly triple our estimates. It could be larger still if there is desirability bias in answering the mask usage survey question, so that the actual increase in mask use may be smaller than our estimate.

[38] Consistent with this result, Seres et al. (2020) find that wearing masks increased physical distancing based on a randomized field experiment in stores in Germany.

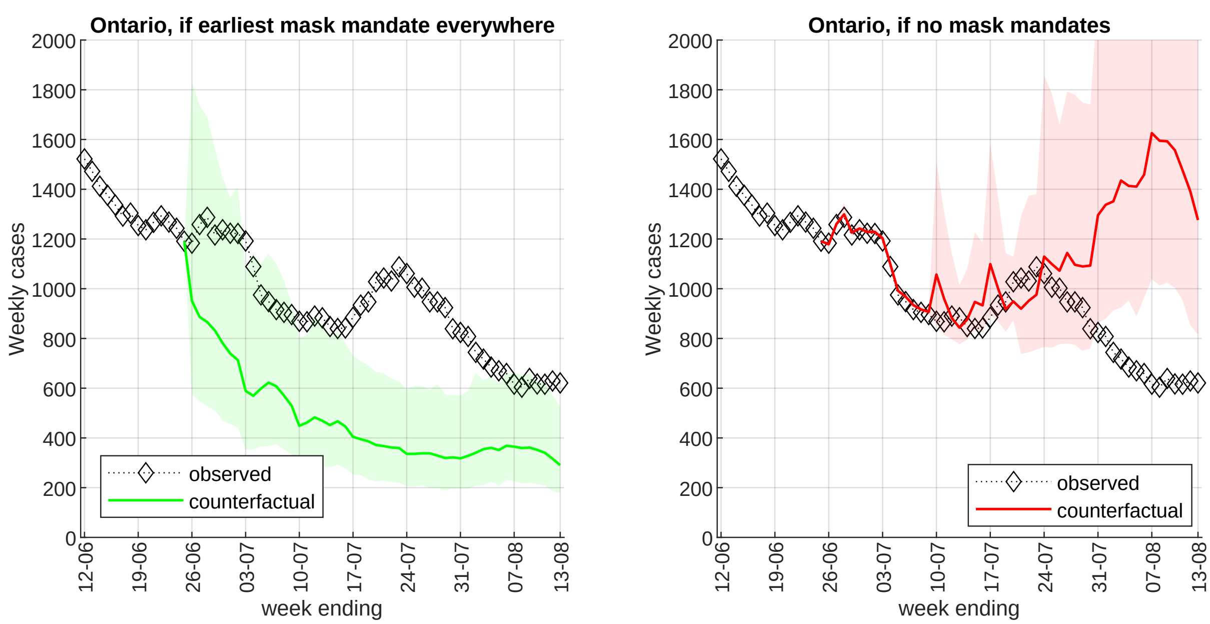
case growth rate, Y^c_{it}, as follows:

$$\Delta C^c_{it} = \exp(Y^c_{it}) \left(\Delta C^c_{it-7}\right) \text{ and}$$

$$Y^c_{it} = \hat{Y}_{it} + \beta_{Mask\_14} \left(\text{Mask}^c\text{\_14} - \text{Mask\_14}\right) + \beta_{log\_dC\_14} \left(\ln(\Delta C^c_{it-14}) - \ln(\Delta C_{it-14})\right),$$

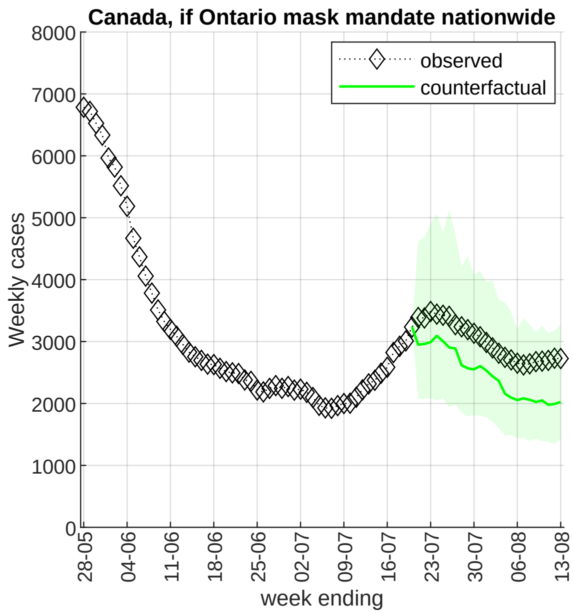
where $\hat{Y}_{it}$ is the regression-fitted value of weekly case growth; β_{Mask_14} is the coefficient estimate on the mask mandate variable Mask_14 in baseline specification (4) in Table 1 or 2, depending on the counterfactual; Mask^c_14 is the counterfactual mask policy (e.g. different implementation date, wider geographic coverage or absence of mask mandate); and $\beta_{log\Delta C\_14}$ is the coefficient estimate (-0.227 or -0.209) on lagged cases $\log(\Delta C)$_14 in Table 1 or 2, column 4. The coefficient $\beta_{log\Delta C\_14}$ adjusts the counterfactual case growth rate for the negative statistically significant association between the weekly case total two weeks prior and time-t case growth. This effect may be due to people being more careful when they perceive the risk of infection to be higher or less careful vice versa.

Figure 6: Counterfactuals - Ontario public health regions



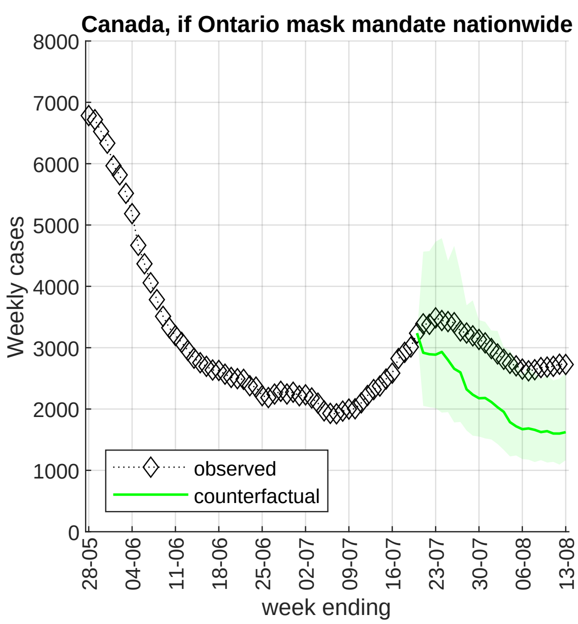
Notes: The left panel assumes that mask mandates were adopted in all PHUs on June 12 (date of the first mask mandate in ON). The right panel assumes that mask mandates were not adopted in any PHU. We use the mask estimate (-0.376) from column (4) of Table 1.

Figure 7: Counterfactuals – Canada (Table 1 mask estimate)



Notes: The left panel assumes that mask mandates were adopted in all provinces on July 7 (the adoption date in Toronto and Ottawa). The right panel assumes that mask mandates were not adopted in any province. We use the mask estimate (-0.376) from column (4) of Table 1.

Figure 8: Counterfactuals – Canada (Table 2 mask estimate)



Notes: The left panel assumes that mask mandates were adopted in all provinces on July 7 (the adoption date in Toronto and Ottawa). The right panel assumes that mask mandates were not adopted in any province. We use the mask estimate (-0.613) from column (4) of Table 2.

Figures 6, 7 and 8 show results from two counterfactual policy evaluations. The first exercise, depicted in the left-hand side panel of the figures, assumes that masks are adopted everywhere at the earliest date observed in the data. Specifically, Figure 6 considers the counterfactual of all Ontario PHUs adopting mask mandates on June 12, while Figures 7 and 8 assume that all provinces adopt a mask mandate on July 7.[39]

Using our mask policy estimate from Table 1, Figure 6 shows that an earlier face mask mandate across Ontario PHUs could have lead to an average reduction of about 300 cases per week as of August 13, holding all else equal. For Canada as a whole, a nation-wide adoption of mask mandates in early July is predicted to reduce total cases per week in the country by 700 to 1,100 cases on average as of August 13, depending on whether we use the more conservative mask estimate (-0.376) from column (4) of Table 1 (see Figure 7) or the larger estimate (-0.613) from column (4) of Table 2 (see Figure 8). In all cases, the indirect feedback effect via $\beta_{log\Delta C\_14}$ (lagged cases as information) starts moderating the decrease in cases two weeks after the start of the counterfactual mask policy.

In the right-hand side panel of Figures 6, 7 and 8, we perform the opposite exercise, namely assuming instead that mask mandates were *not* adopted in any Ontario PHU or any Canadian province. Our estimates imply that the counterfactual absence of mask mandates would have led to a large increase in new cases, both in Ontario and Canada-wide, especially when using the larger mask coefficient estimate from Table 2 (see Figure 8).

Finally, in Figure B11 in the Appendix, we also evaluate the counterfactual in which British Columbia and Alberta, the third and fourth largest Canadian provinces by population, adopt province-wide mask mandates on July 15. The results, using the Mask_14 estimate from Table 2, suggest a reduction of about 300 cases per week in each province by mid-August.

The counterfactual simulations assume that all other variables, behaviour and policies (except the mask policy and $t - 14$ cases) remain fixed, as observed in the data. This is a strong assumption, but it may be plausible over the relatively short time period that we analyze. Moreover, the counterfactuals assume that regions without a mask mandate would react in the same way, on average, as the regions that imposed a mandate. Therefore, these results should be interpreted with caution and only offer a rough illustration and projection of the estimated effect of mask mandates on COVID-19 cases.

[39] June 12 is the date of the earliest mask mandate in Ontario. For the national analysis, July 7, the effective date for Toronto and Ottawa, is considered Ontario's first significant date of mask mandate enactment: PHUs with earlier mandates account for less than 10% of Ontario's population.

4.6 Additional analysis

Closing and re-opening sub-periods

We investigate whether policy impact varied in different phases of the pandemic by splitting the full sample period into two sub-periods: "closing" (March 11 to May 14) and "re-opening" (May 15 to August 13). The dividing date of May 15 (referring to the NPIs in place around May 1) was chosen because very few policies were relaxed before May 1, and very few non-mask policies were tightened after May 1 in our sample period (see Figure 2).

In Table A15, we report estimates and wild bootstrap standard errors using our baseline specification with cubic time trend, separately for the closing and re-opening periods. We find that the imposition of school closures and travel restrictions early in the closing period is associated with a very large subsequent reduction in weekly case growth, as can be also seen on Figure B8 – the average observed log growth rate of cases $\Delta \log(\Delta \mathrm{C})$ falls from 2.4 (ten-fold growth in weekly cases) to -0.4 (33% decrease in weekly cases) between March 15 and April 5. Long-term care restrictions are also associated with reduced case growth two weeks later during the March to May closing period. We interpret these results with caution, however, since many of these policy measures and restrictions were enacted in a brief time interval during March and there is not much inter-provincial variation (see Figure 2). No mask mandates were present in the closing period.

In the re-opening period, our results in Table A15 are in line with our full-sample results for mask mandates and business/gathering regulations (Table 2), with slightly larger coefficient estimates and less statistically significant p-values, possibly due to the smaller sample. Travel and school closures are not statistically significant in the re-opening period. This is unsurprising: relaxation of travel policies was minor and endogenous (only re-open to safe areas within Canada), and the schools that re-opened (in parts of Quebec and, on a part-time basis, in British Columbia) did so on voluntary attendance basis, yielding smaller class sizes.

Deaths

We also examine the weekly death growth as an outcome. We only have access to disaggregated deaths data at the province level (not at PHU levels in Ontario). We thus estimate regression equation (1) using $Y_{it} = \Delta \log(\Delta D_{it})$ for each province i as the dependent variable. In addition, we use a 28-day lag for the policy, behaviour proxy, and information variables to reflect the fact that deaths occur on average about two weeks after case detection; see Appendix D for details and references.[40]

[40] In Table 4, *Variable*_28 denotes the *Variable* lagged by 28 days.

Table 4 reports the estimates from the same specifications as those for case growth in Table 2. In all specifications, mask mandates are associated with a large reduction in the observed weekly deaths growth rate four weeks later (more than 90 log points, or equivalently more than 60% reduction in weekly deaths). These results are larger than our case growth results, but consistent with them given the substantial uncertainty. See also Figure B12, which plots the average weekly death growth in the provinces without a mask mandate four weeks prior vs. that for Ontario, the only province with mask mandate four weeks prior in our sample period.

The robustness checks in Table A16, however, show that, unlike for case growth, the mask mandate estimates in Table 4 are not robust to weighing by population or to restricting the sample to the largest 4 provinces. This suggests that the estimated effect is largely driven by observations from the small provinces, which have a disproportionately larger number of zero or small weekly death totals.[41] Furthermore, given the 28-day lag, there are only 9 days with observations (from Ontario only) for which the mask mandate variable takes value of 1. Due to these serious data limitations, the relation between mask mandates and COVID-19 deaths in Table 4 is suggestive at best, and we urge caution in interpreting or extrapolating from these results.

That said, our main findings about the growth in cases may have implications about future growth in deaths, particularly if the affected demographics become less skewed toward the young in later periods.

[41] 205 out of the 1,470 observations (14%) had log(0) replaced by -1.

Table 4: Canada – deaths growth rate and policies

	Outcome: weekly deaths growth, $\Delta\log(\Delta D)$					
	(1)	(2)	(3)	(4)	(5)	(6)
	no time trend		cubic time trend		week fixed effects	
Mask_28	-1.391 ***	-1.453 ***	-0.922 **	-0.983 **	-0.904 **	-0.915 **
	[0.000]	[0.000]	[0.022]	[0.032]	[0.036]	[0.045]
Business/gathering_28	0.241	0.271	-0.134	-0.224	-0.279	-0.268
	[0.529]	[0.521]	[0.762]	[0.748]	[0.712]	[0.732]
School_28	0.002	0.018	0.441	0.440	0.624	0.630
	[0.974]	[0.924]	[0.317]	[0.341]	[0.114]	[0.113]
Travel_28	-0.176	-0.287	-0.005	-0.027	-0.191	-0.161
	[0.553]	[0.432]	[0.972]	[0.935]	[0.638]	[0.718]
Long-term care_28	-0.091	-0.140	-0.035	-0.036	-0.024	-0.017
	[0.592]	[0.600]	[0.900]	[0.900]	[0.936]	[0.948]
Behaviour proxy_28	0.003	0.000	0.002	0.003	0.005	0.005
	[0.718]	[1.000]	[0.815]	[0.737]	[0.675]	[0.695]
$\Delta\log(\Delta\mathrm{D})$_28	0.151	0.175	0.141	0.152	0.154	0.153
	[0.194]	[0.245]	[0.361]	[0.345]	[0.266]	[0.266]
$\log(\Delta\mathrm{D})$_28	-0.238 ***	-0.248 ***	-0.216 ***	-0.220 ***	-0.229 ***	-0.227 ***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
$\Delta\log(\Delta\mathrm{ND})$_28		-0.110		-0.121		-0.019
		[0.471]		[0.476]		[0.806]
$\log(\Delta\mathrm{ND})$_28		-0.015		0.018		-0.053
		[0.743]		[0.858]		[0.557]
$\Delta\log(\Delta\mathrm{T})$	0.081	0.018	-0.038	-0.051	-0.037	-0.037
	[0.409]	[0.922]	[0.758]	[0.735]	[0.752]	[0.748]
R-squared	0.233	0.239	0.251	0.254	0.286	0.286
N	1,470	1,470	1,470	1,470	1,470	1,470
province fixed effects	X	X	X	X	X	X
cubic trend in days			X	X		
week fixed effects					X	X

Notes: The time period is March 11 to August 13, 2020. P-values from wild bootstrap (cgmwildboot) standard errors clustered by province with 5000 repetitions are reported in the square brackets. ***, ** and * denote 10%, 5% and 1% significance level respectively. ND denotes national total deaths.

5 Conclusion

The wearing of face masks by the general public has been a very contentious policy issue during the COVID-19 pandemic, with health authorities in many countries and the World Health Organization giving inconsistent or contradictory recommendations over time. "Conspiracy theories" and misinformation surrounding mask wear abound in social media, fuelled by some individuals' perception that mask mandates constitute significant restrictions on individual freedoms. Given the absence of large-scale randomized controlled trials or other direct evidence on mask effectiveness in preventing the spread of COVID-19, quantitative observational studies like ours are essential for informing both public policy and the public opinion.

We estimate the impact of mask mandates and other public policy measures on the spread of COVID-19 in Canada. We use both within-province and cross-province variation in the timing of mask mandates and find a robust and significantly negative association between mask mandates and subsequent COVID-19 case growth – 25 to 46% average reduction in weekly cases in the first several weeks after adoption, depending on the data sample and empirical specification used. These results are supported by our analysis of survey data on compliance with the mask mandates, which show that the mandates increase the proportion of reporting as always wearing a mask in public by around 30 percentage points. However, our sample period does not allow us to determine whether their effect lasts beyond the first few weeks after implementation. We conclude that mask mandates can be a powerful policy tool for at least temporarily reducing the spread of COVID-19.

Mask mandates were introduced in Canada during a period where other policy measures were relaxed, as part of the economy's re-opening. Specifically, we find that relaxed restrictions on businesses or gatherings are positively associated with subsequent COVID-19 case growth – a factor that could offset and obscure the health benefits of mask mandates. Past case totals were also found to matter for subsequent COVID-19 outcomes, suggesting that riskier behaviour based on favourable lagged information may limit how low mask mandates and other restrictions – short of a lockdown – can push the number of new cases.

We have deliberately abstained from studying the direct economic impacts of COVID-19, focusing instead on the unique features of the Canadian data for identifying the effect of NPIs, in particular mask mandates, on COVID-19 case growth. Future research combining epidemiological finding with the economic benefits and costs of various public policies or restrictions would enrich the ongoing policy debate and provide further guidance.

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Appendix A. Additional tables

Table A1: Ontario – Correlations between the Google mobility indicators

category	retail	grocery	workplaces	transit	residential	parks	N
retail	1						3,008
grocery	0.82	1					3,064
workplaces	0.39	0.26	1				3,082
transit	0.57	0.47	0.65	1			2,453
residential	-0.54	-0.38	-0.92	-0.69	1		2,751
parks	0.50	0.31	0.40	0.40	-0.47	1	1,483

Notes: The time period is May 1 to July 30 (two weeks before the May 15 - August 13 sample period). Daily PHU-level data.

Table A2: Canada – Correlations between the Google mobility indicators

category	retail	grocery	workplaces	transit	residential	parks	N
retail	1						1,560
grocery	0.84	1					1,560
workplaces	0.69	0.53	1				1,560
transit	0.82	0.60	0.86	1			1,394
residential	-0.80	-0.58	-0.91	-0.85	1		1,516
parks	0.53	0.43	0.19	0.25	-0.46	1	1,347

Notes: The time period is February 26 to July 30 (two weeks before the March 11 - August 13 sample period). Daily province-level data.

Table A3: Ontario – Correlations between policies and location behaviour

	Behaviour proxy	Mask	Business/gathering	LTC
Behaviour proxy	1			
Mask	0.17	1		
Business/gathering	-0.55	-0.63	1	
Long-term care (LTC)	-0.27	-0.75	0.66	1

Notes: The time period is May 15 to August 13 ($N = 3,094$). Each variable is a 7-day moving average. All variables are at the PHU level, except LTC which is measured at the province level.

Table A4: Canada – Correlations between policies and location behaviour

	Behaviour proxy	Mask	Business/gathering	School	Travel	LTC
Behaviour proxy	1					
Mask	0.09	1				
Business/gathering	-0.86	-0.23	1			
School	-0.37	0.08	0.37	1		
Travel	-0.14	-0.09	0.30	0.61	1	
Long-term care (LTC)	-0.14	-0.11	0.24	0.44	0.22	1

Notes: The time period is March 11 to August 13 ($N = 1,560$). Province-level, 7-day moving averages.

Table A5: Ontario – Robustness (treatment of zero weekly cases)

	Outcome: weekly case growth, $\Delta\log(\Delta C)$							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Baseline		Alternative 1		Alternative 2		Alternative 3	
p-values in [ ] brackets	replace log(0) by -1		replace log(0) by 0		add 1 before taking log		weighted by population	
Mask_14	-0.366 **	-0.376 ***	-0.310 **	-0.315 ***	-0.272 **	-0.280 **	-0.249 *	-0.259 *
	[0.010]	[0.008]	[0.010]	[0.008]	[0.017]	[0.013]	[0.096]	[0.082]
Business/	-0.137	0.279	0.021	0.290	-0.006	0.270	0.350	0.529 *
gathering_14	[0.877]	[0.689]	[0.945]	[0.613]	[1.000]	[0.616]	[0.226]	[0.092]
Long-term care_14	0.747	-0.097	-0.003	-0.568	0.196	-0.327	-1.652	-1.927 *
	[0.677]	[0.930]	[0.973]	[0.667]	[0.908]	[0.782]	[0.137]	[0.070]
Behaviors_14	-0.018	-0.018	-0.016	-0.016	-0.013	-0.014	-0.008	-0.009
	[0.266]	[0.272]	[0.188]	[0.194]	[0.278]	[0.270]	[0.416]	[0.418]
$\Delta\log(\Delta C)$_14	0.024	0.028	0.043	0.045	0.028	0.030	0.038	0.038
	[0.692]	[0.665]	[0.330]	[0.322]	[0.520]	[0.494]	[0.578]	[0.562]
$\log(\Delta C)$_14	-0.203 ***	-0.209 ***	-0.184 ***	-0.188 ***	-0.164 ***	-0.169 ***	-0.223 ***	-0.231 ***
	[0.001]	[0.001]	[0.001]	[0.000]	[0.001]	[0.001]	[0.000]	[0.000]
$\Delta\log(\Delta PC)$_14		0.184		0.132		0.094		0.066
		[0.566]		[0.647]		[0.722]		[0.696]
$\log(\Delta PC)$_14		0.528		0.302		0.437		0.300
		[0.124]		[0.302]		[0.101]		[0.257]
$\Delta\log(\Delta T)$	-0.260	-0.382	-0.189	-0.266	-0.129	-0.215	-0.012	-0.063
	[0.287]	[0.125]	[0.361]	[0.203]	[0.486]	[0.242]	[0.942]	[0.677]
R-squared	0.051	0.058	0.059	0.062	0.057	0.063	0.066	0.069
N	3,094	3,094	3,094	3,094	3,094	3,094	3,094	3,094
PHU fixed effects	X	X	X	X	X	X	X	X
cubic time trend	X	X	X	X	X	X	X	X
population weighted	No	No	No	No	No	No	Yes	Yes

Notes: The time period is May 15 to August 13, 2020. P-values from wild bootstrap (cgmwildboot) standard errors clustered by public health unit (PHU) with 5000 repetitions are reported in the square brackets. Columns (1) and (2) repeat columns (3) and (4) from Table 1 where we replace log(0) with -1. Columns (3) and (4) replace log(0) with 0, and columns (5) and (6) add 1 to all ΔC_{it} observations. Columns (7) and (8) report estimates from a weighted least squares regression with weights equal to the PHU population sizes. ***, ** and * denote 10%, 5% and 1% significance level respectively.

Table A6: Ontario – Robustness (standard errors)

Outcome: weekly case growth $\Delta\log(\Delta C)$				
	(1)		(2)	
Mask_14	-0.366		-0.376	
	(0.014)	**	(0.012)	**
	[0.010]	**	[0.008]	***
	{0.022}	**	{0.016}	**
Business/gathering_14	-0.137		0.279	
	(0.849)		(0.688)	
	[0.877]		[0.689]	
	{0.887}		{0.703}	
Long-term care_14	0.747		-0.097	
	(0.657)		(0.951)	
	[0.677]		[0.930]	
	{0.702}		{0.935}	
Behaviour proxy_14	-0.018		-0.018	
	(0.183)		(0.197)	
	[0.266]		[0.272]	
	{0.281}		{0.272}	
R-squared	0.054		0.060	
N	3,094		3,094	
$\Delta\log(\Delta C)$_14	X		X	
$\log(\Delta C)$_14	X		X	
$\Delta\log(\Delta PC)$_14			X	
$\log(\Delta PC)$_14			X	
$\Delta\log(\Delta T)$	X		X	
PHU fixed effects	X		X	
cubic time trend	X		X	

Notes: The time period is May 15 - August 13. P-values from standard clustering by PHU (Stata command cluster) in the ( ) parentheses, wild bootstrap with one-way clustering by PHU and 5000 repetitions in the [ ] square brackets, and wild bootstrap with two-way clustering by PHU and day with 5000 repetitions in the { } curly braces. PC denotes provincial cases.

Table A7: Ontario – Robustness (policy collinearity)

	Outcome: weekly case growth $\Delta\log(\Delta C)$							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Baseline		Drop Mask_14		Drop Business/gathering_14		Drop LTC_14	
Mask_14	-0.366 **	-0.376 **			-0.362 **	-0.382 ***	-0.363 **	-0.376 ***
	[0.010]	[0.008]			[0.012]	[0.009]	[0.010]	[0.008]
Business/gathering_14	-0.137	0.279	-0.041	0.398			-0.047	0.260
	[0.877]	[0.689]	[0.976]	[0.565]			[0.947]	[0.682]
Long-term care (LTC)_14	0.747	-0.097	0.650	-0.271	0.653	0.229		
	[0.677]	[0.930]	[0.728]	[0.836]	[0.682]	[0.890]		
Behaviour proxy_14	-0.018	-0.018	-0.014	-0.014	-0.017	-0.019	-0.018	-0.018
	[0.266]	[0.272]	[0.323]	[0.336]	[0.199]	[0.174]	[0.268]	[0.268]
$\Delta\log(\Delta C)$_14	0.024	0.028	0.035	0.039	0.025	0.027	0.027	0.027
	[0.692]	[0.665]	[0.541]	[0.512]	[0.696]	[0.676]	[0.678]	[0.669]
$\log(\Delta C)$_14	-0.203 ***	-0.209 ***	-0.215 ***	-0.221 ***	-0.202 ***	-0.210 ***	-0.206 ***	-0.209 ***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.000]	[0.001]
$\Delta\log(\Delta PC)$_14		0.184		0.217		0.122		0.174
		[0.566]		[0.485]		[0.722]		[0.611]
$\log(\Delta PC)$_14		0.528		0.486		0.544		0.532
		[0.124]		[0.158]		[0.115]		[0.132]
$\Delta\log(\Delta T)$	-0.260	-0.382	-0.243	-0.367	-0.263	-0.364	-0.239	-0.382
	[0.287]	[0.125]	[0.322]	[0.136]	[0.291]	[0.162]	[0.287]	[0.125]
R-squared	0.051	0.058	0.049	0.054	0.054	0.060	0.053	0.060
N	3,094	3,094	3,094	3,094	3,094	3,094	3,094	3,094
public health unit FE	X	X	X	X	X	X	X	X
cubic time trend	X	X	X	X	X	X	X	X

Notes: The time period is May 15 to August 13, 2020. P-values from wild bootstrap (cgmwildboot) standard errors clustered by public health unit (PHU) with 5000 repetitions are reported in the square brackets. Columns (1) and (2) repeat columns (3) and (4) from Table 1. We drop each policy at at time in columns (3)-(8). ***, ** and * denote 10%, 5% and 1% significance level respectively.

Table A8: Canada - Robustness (treatment of zero weekly cases)

	Outcome: Weekly case growth, $\Delta\log(\Delta C)$									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Baseline Replace log(0) by -1		Alternative 1 Replace log(0) by 0		Alternative 2 Add 1 before taking log		Alternative 3 Weighted by population		Alternative 4 4 largest provinces	
Mask_14	-0.618 ***	-0.613 ***	-0.599 ***	-0.591 ***	-0.594 ***	-0.587 ***	-0.618 ***	-0.613 ***	-0.593 ***	-0.588 ***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Business / gathering_14	-0.835 **	-0.846 **	-0.794 *	-0.812 *	-0.698 **	-0.711 *	-0.224	-0.216	0.049	0.160
	[0.031]	[0.033]	[0.076]	[0.070]	[0.046]	[0.055]	[0.513]	[0.615]	[0.754]	[0.509]
School_14	-0.425 **	-0.433 **	-0.393 **	-0.410 **	-0.366 **	-0.381 **	-0.148	-0.211 **	-0.029	-0.060
	[0.015]	[0.019]	[0.023]	[0.020]	[0.050]	[0.042]	[0.278]	[0.010]	[0.599]	[0.478]
Travel_14	-0.375	-0.412	-0.499	-0.565	-0.283	-0.338	-1.513 *	-1.811 *	-2.368	-4.980 ***
	[0.613]	[0.636]	[0.446]	[0.437]	[0.646]	[0.630]	[0.077]	[0.071]	[0.358]	[0.000]
LTC_14	0.023	0.032	0.093	0.108	0.051	0.063	0.097	0.119	-0.054	-0.076
	[0.958]	[0.920]	[0.772]	[0.746]	[0.866]	[0.831]	[0.360]	[0.274]	[0.626]	[0.132]
Behaviour_14	-0.001	0.000	-0.002	0.000	0.001	0.002	-0.015 *	-0.013	-0.025 ***	-0.030 ***
	[0.880]	[0.972]	[0.864]	[0.946]	[0.910]	[0.692]	[0.054]	[0.100]	[0.000]	[0.000]
$\Delta\log(\Delta C)$_14	-0.078 *	-0.072	-0.034	-0.025	-0.042	-0.035	0.002	0.005	0.036	0.023
	[0.090]	[0.198]	[0.456]	[0.599]	[0.221]	[0.359]	[1.000]	[0.942]	[0.611]	[0.746]
$\log(\Delta C)$_14	-0.227 **	-0.227 *	-0.236 ***	-0.236 ***	-0.209 ***	-0.210 **	-0.265 ***	-0.276 ***	-0.281	-0.290 ***
	[0.019]	[0.090]	[0.000]	[0.000]	[0.000]	[0.012]	[0.000]	[0.000]	[0.109]	[0.000]
$\Delta\log(\Delta NC)$_14		-0.107		-0.180		-0.144		-0.174 ***		-0.297 ***
		[0.631]		[0.335]		[0.384]		[0.000]		[0.000]
$\log(\Delta NC)$_14		0.055		0.100		0.085		0.255		0.615 ***
		[0.825]		[0.738]		[0.731]		[0.295]		[0.000]
$\Delta\log(\Delta T)$	0.172 **	0.169 *	0.098 *	0.093	0.113 *	0.109	0.079	0.074	0.072	0.071
	[0.043]	[0.056]	[0.094]	[0.130]	[0.075]	[0.109]	[0.776]	[0.781]	[0.754]	[0.639]
R-squared	0.414	0.414	0.483	0.484	0.471	0.471	0.651	0.653	0.804	0.813
N	1,560	1,560	1,560	1,560	1,560	1,560	1,560	1,560	624	624
Province FE	X	X	X	X	X	X	X	X	X	X
Cubic trend	X	X	X	X	X	X	X	X	X	X
Weighted	No	No	No	No	No	No	Yes	Yes	No	No

Notes: The time period is March 11 to August 13, 2020. P-values from wild bootstrap (cgmwildboot) standard errors clustered by province with 5000 repetitions in the square brackets. Columns (1) and (2) repeat columns (3) and (4) from Table 2 where we replace log(0) with -1. Columns (3) and (4) replace log(0) with 0, and columns (5) and (6) add 1 to all ΔC_{it} observations. Columns (7) and (8) report results from a weighted least squares regression with the province populations as weights. Finally, columns (9) and (10) restrict the sample to only the largest 4 provinces (BC, ON, QC, and AB) which have only 0.3% zero observation cases. ***, ** and * denote 10%, 5% and 1% significance level respectively.

Table A9: Canada – Robustness (standard errors)

Outcome: weekly case growth $\Delta\log(\Delta C)$	(1)		(2)	
Mask_14	-0.618		-0.613	
	(0.014)	**	(0.014)	**
	[0.000]	***	[0.000]	***
	{0.000}	***	{0.000}	***
Business/gathering_14	-0.835		-0.846	
	(0.027)	**	(0.023)	**
	[0.031]	**	[0.033]	**
	{0.035}	**	{0.039}	**
School_14	-0.425		-0.433	
	(0.042)	**	(0.025)	**
	[0.015]	**	[0.019]	**
	{0.015}	**	{0.014}	**
Travel_14	-0.375		-0.412	
	(0.526)		(0.534)	
	[0.613]		[0.636]	
	{0.612}		{0.637}	
Long-term care_14	0.023		0.032	
	(0.948)		(0.926)	
	[0.958]		[0.920]	
	{0.958}		{0.920}	
Behaviour proxy_14	-0.001		0.000	
	(0.857)		(0.962)	
	[0.880]		[0.972]	
	{0.878}		{0.972}	
R-squared	0.406		0.410	
N	1,560		1,560	
$\Delta\log(\Delta C)$_14	X		X	
$\log(\Delta C)$_14	X		X	
$\Delta\log(\Delta NC)$_14			X	
$\log(\Delta NC)$_14			X	
$\Delta\log(\Delta T)$	X		X	
province fixed effects	X		X	
cubic time trend	X		X	

Notes: The time period is March 11 - August 13. P-values from standard clustering by province in the ( ) parentheses, wild bootstrap with one-way clustering by province and 5000 repetitions in the [ ] square brackets, and wild bootstrap with two-way clustering by province and day with 5000 repetitions in the { } curly braces.

Table A10: Canada - Robustness (policy collinearity)

	Outcome: weekly case growth, $\Delta \log(\Delta C)$									
	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	drop Mask_14		drop Business /gathering_14		drop School_14		drop Travel_14		drop LTC_14	
Mask_14			-0.621 ***	-0.614 ***	-0.588 ***	-0.592 ***	-0.635 ***	-0.636 ***	-0.618 ***	-0.614 ***
			[0.000]	[0.000]	[0.006]	[0.004]	[0.000]	[0.004]	[0.000]	[0.000]
Business/ gathering_14	-0.837 **	-0.847 **			-0.827 **	-0.847 **	-0.895 **	-0.909 **	-0.829 **	-0.837 **
	[0.033]	[0.040]			[0.031]	[0.034]	[0.012]	[0.013]	[0.035]	[0.030]
School_14	-0.389 **	-0.406 **	-0.413 **	-0.434 **			-0.494 ***	-0.476 **	-0.419 **	-0.424 **
	[0.040]	[0.041]	[0.019]	[0.042]			[0.008]	[0.018]	[0.013]	[0.036]
Travel_14	-0.421	-0.472	-0.571	-0.623	-0.525	-0.502			-0.383	-0.422
	[0.548]	[0.566]	[0.378]	[0.411]	[0.445]	[0.556]			[0.544]	[0.562]
LTC_14	0.024	0.033	-0.075	-0.069	-0.041	-0.028	0.061	0.068		
	[0.961]	[0.908]	[0.842]	[0.848]	[0.918]	[0.926]	[0.850]	[0.821]		
Behaviour_14	-0.001	0.000	0.007	0.008	0.003	0.003	0.001	0.001	-0.002	0.000
	[0.883]	[0.982]	[0.527]	[0.338]	[0.767]	[0.704]	[0.826]	[0.814]	[0.856]	[0.930]
$\Delta\log(\Delta C)$_14	-0.074	-0.069	-0.059	-0.055	-0.084 *	-0.077	-0.089 **	-0.083 *	-0.078 *	-0.072
	[0.110]	[0.217]	[0.180]	[0.302]	[0.069]	[0.184]	[0.043]	[0.095]	[0.078]	[0.172]
$\log(\Delta C)$_14	-0.227 **	-0.228 *	-0.230 ***	-0.232 *	-0.227 **	-0.223	-0.214 ***	-0.211 **	-0.228 ***	-0.228 **
	[0.019]	[0.090]	[0.007]	[0.068]	[0.036]	[0.107]	[0.002]	[0.040]	[0.000]	[0.034]
$\Delta\log(\Delta NC)$_14		-0.122		-0.092		-0.071		-0.063		-0.106
		[0.572]		[0.659]		[0.755]		[0.820]		[0.642]
$\log(\Delta NC)$_14		0.080		0.083		-0.036		-0.022		0.054
		[0.743]		[0.742]		[0.893]		[0.932]		[0.823]
$\Delta\log(\Delta T)$	0.170 *	0.167 *	0.153 *	0.151	0.174 **	0.169 *	0.180 *	0.176 *	0.173 **	0.170 **
	[0.055]	[0.072]	[0.080]	[0.102]	[0.048]	[0.060]	[0.060]	[0.070]	[0.024]	[0.037]
R-squared	0.410	0.411	0.408	0.408	0.412	0.412	0.413	0.413	0.414	0.414
N	1,560	1,560	1,560	1,560	1,560	1,560	1,560	1,560	1,560	1,560
Province FE	X	X	X	X	X	X	X	X	X	X
Cubic in days	X	X	X	X	X	X	X	X	X	X

Notes: The time period is March 11 to August 13, 2020. P-values from wild bootstrap (cgmwildboot) standard errors clustered by province with 5000 repetitions are reported in the square brackets. We drop each policy one at a time in columns (3)-(12). ***, ** and * denote 10%, 5% and 1% significance level respectively.

Table A11: Canada – Robustness (news and weather)

	Outcome: weekly case growth $\Delta\log(\Delta C)$					
	(1)	(2)	(3)	(4)	(5)	(6)
	baseline		add weather		add news	
Mask_14	-0.618 ***	-0.613 ***	-0.676 **	-0.666 **	-0.629 ***	-0.616 ***
	[0.000]	[0.000]	[0.020]	[0.026]	[0.000]	[0.002]
Business/ gathering_14	-0.835 **	-0.846 **	-0.903 *	-0.912 *	-0.884 **	-0.892 **
	[0.031]	[0.033]	[0.078]	[0.070]	[0.018]	[0.024]
School_14	-0.425 **	-0.433 **	-0.497 *	-0.528 *	-0.297	-0.292
	[0.015]	[0.019]	[0.068]	[0.085]	[0.205]	[0.111]
Travel_14	-0.375	-0.412	-0.242	-0.318	-0.302	-0.415
	[0.613]	[0.636]	[0.777]	[0.727]	[0.687]	[0.627]
Long-term care_14	0.023	0.032	0.052	0.063	0.043	0.056
	[0.958]	[0.920]	[0.908]	[0.884]	[0.900]	[0.881]
Behaviour proxy_14	-0.001	0.000	-0.002	-0.001	-0.001	0.002
	[0.880]	[0.972]	[0.868]	[0.962]	[0.918]	[0.814]
$\Delta\log(\Delta C)$_14	-0.078 *	-0.072	-0.083 *	-0.078	-0.071	-0.072
	[0.090]	[0.198]	[0.068]	[0.170]	[0.118]	[0.202]
$\log(\Delta C)$_14	-0.227 **	-0.227 *	-0.221 *	-0.224	-0.216 *	-0.221
	[0.019]	[0.090]	[0.054]	[0.120]	[0.090]	[0.110]
$\Delta\log(\Delta NC)$_14		-0.107		-0.136		-0.066
		[0.631]		[0.470]		[0.774]
$\log(\Delta NC)$_14		0.055		0.130		0.338
		[0.825]		[0.612]		[0.332]
$\Delta\log(\Delta T)$	0.172 **	0.169 *	0.189 **	0.187 *	0.161 *	0.158 *
	[0.043]	[0.056]	[0.033]	[0.052]	[0.064]	[0.078]
Rain_14			0.053	0.054		
			[0.189]	[0.177]		
Max temp_14			0.037	0.039		
			[0.434]	[0.389]		
Min temp_14			-0.031	-0.034		
			[0.562]	[0.519]		
News_14					-0.003	-0.007
					[0.278]	[0.103]
R-squared	0.414	0.414	0.419	0.419	0.415	0.416
N	1,560	1,560	1,560	1,560	1,560	1,560
Province FE	X	X	X	X	X	X
Cubic in days	X	X	X	X	X	X
Weather			X	X		
News					X	X

Notes: The time period is March 11 to August 13, 2020. P-values from wild bootstrap (cgmwildboot) standard errors clustered by province with 5000 repetitions are reported in the square brackets. Columns (1) and (2) repeat columns (3) and (4) from Table 2. Columns (3) and (4) report estimates with lagged weather variables as additional controls. Columns (5) and (6) add a "news" variable to the baseline specification (see Appendix C for more details). ***, ** and * denote 10%, 5% and 1% significance level respectively.

Table A12: Self-reported Mask Usage (“Always” or “Frequently”) – Canada

	Outcome: Wear mask “Always” or “Frequently”					
	(1)	(2)	(3)	(4)	(5)	(6)
	no time trend		cubic time trend		week fixed effects	
Mask	0.371 ***	0.354 ***	0.217 ***	0.215 ***	0.212 ***	0.211 ***
	[0.000]	[0.000]	[0.002]	[0.006]	[0.000]	[0.000]
$\Delta\log(\Delta C)$	-0.029	-0.015	-0.017 **	-0.015 *	-0.016 **	-0.019 **
	[0.503]	[0.164]	[0.032]	[0.086]	[0.047]	[0.021]
$\log(\Delta C)$	-0.037 *	0.028 ***	0.015 ***	0.015 **	0.016 ***	0.016 **
	[0.079]	[0.004]	[0.000]	[0.031]	[0.002]	[0.012]
$\Delta\log(\Delta NC)$		-0.158 **		-0.044		0.185
		[0.036]		[0.236]		[0.132]
$\log(\Delta NC)$		-0.148 ***		0.025		-0.024
		[0.000]		[0.582]		[0.907]
R-squared	0.132	0.162	0.173	0.173	0.174	0.175
N	8,859	8,859	8,859	8,859	8,859	8,859
mean wo mask mandates	0.464	0.464	0.464	0.464	0.464	0.464
individual characteristics	X	X	X	X	X	X
province fixed effects	X	X	X	X	X	X
cubic time trend (days)			X	X		
week fixed effects					X	X

Notes: The time period is April 2 to August 13, 2020. P-values from wild bootstrap (cgmwildboot) standard errors clustered by province with 5000 repetitions are reported in the square brackets. NC denotes national total cases. The data source is YouGov. The outcome is a dummy which takes one for the respondent who answers “Always” or “Frequently” to the survey question “Thinking about the last 7 days, how often have you worn a face mask outside your home?” Sample weights are used. Individual characteristics include a gender dummy, dummies for each age (in years), dummies for each household size, dummies for each number of children, and dummies for each employment status. ***, ** and * denote 10%, 5% and 1% significance level respectively.

Table A13: Self-reported precautions – Canada

	Outcome: "Always" response							
	(1) wash hands	(2) use sanitizer	(3) avoid going out in general	(4) avoid small gatherings	(5) avoid medium gatherings	(6) avoid large gatherings	(7) avoid crowded areas	(8) avoid touching objects
Mask	-0.013	-0.013	0.014	0.047	0.015	0.058	0.083 *	0.030
	[0.560]	[0.864]	[0.452]	[0.122]	[0.766]	[0.386]	[0.069]	[0.417]
$\Delta\log(\Delta C)$	0.006	0.006	0.003	0.002	0.011	0.007	0.021 **	-0.003
	[0.348]	[0.512]	[0.607]	[0.914]	[0.385]	[0.562]	[0.016]	[0.748]
$\log(\Delta C)$	-0.011 *	-0.005	0.013 **	0.019 *	0.011	0.011	0.011	0.011
	[0.071]	[0.523]	[0.021]	[0.056]	[0.556]	[0.348]	[0.388]	[0.162]
$\Delta\log(\Delta NC)$	-0.031	-0.025	-0.028	0.069 ***	-0.012	0.008	-0.030	-0.038
	[0.333]	[0.518]	[0.420]	[0.000]	[0.740]	[0.726]	[0.296]	[0.264]
$\log(\Delta NC)$	0.063 ***	0.066	-0.014	-0.012	0.043	0.004	0.051	0.033
	[0.002]	[0.256]	[0.725]	[0.806]	[0.461]	[0.937]	[0.424]	[0.525]
R-squared	0.045	0.049	0.048	0.133	0.146	0.126	0.081	0.042
N	8,859	8,859	8,859	8,859	8,859	8,859	8,859	8,859
individual characteristics	X	X	X	X	X	X	X	X
province FE	X	X	X	X	X	X	X	X
cubic trend (in days)	X	X	X	X	X	X	X	X
average w/o mask mandate	0.719	0.477	0.274	0.470	0.601	0.770	0.654	0.491
survey item # (i12_)	health_2	health_3	health_6	health_12	health_13	health_14	health_15	health_20

Notes: The time period is April 2 to August 13, 2020. P-values from wild bootstrap (cgmwildboot) standard errors clustered by province with 5000 repetitions are reported in the square brackets. NC denotes national total cases. The data source is YouGov. The outcome is a dummy which takes value 1 if the respondent answered "Always" to each survey question listed in Table C4. Sample weights are used. Individual characteristics include a gender dummy, age dummy (in years), dummies for each household size, dummies for each number of children, and dummies for each employment status. ***, ** and * denote 10%, 5% and 1% significance level respectively.

Table A14: Self-reported precautions – Canada (continued)

	Outcome: "Always" or "Frequently" response							
	(1) wash hands	(2) use sanitizer	(3) avoid going out in general	(4) avoid small gatherings	(5) avoid medium gatherings	(6) avoid large gatherings	(7) avoid crowded areas	(8) avoid touching objects
Mask	-0.005	0.003	0.035	0.046	0.009	0.050	0.074 ***	0.016
	[0.858]	[0.899]	[0.272]	[0.192]	[0.869]	[0.140]	[0.009]	[0.717]
$\Delta\log(\Delta C)$	-0.001	0.002	-0.006	-0.010	-0.004	-0.005	0.006	-0.005
	[0.716]	[0.775]	[0.568]	[0.167]	[0.688]	[0.614]	[0.291]	[0.666]
$\log(\Delta C)$	0.000	-0.004	0.018 ***	0.017 ***	0.012	0.005	0.009	-0.001
	[0.938]	[0.596]	[0.000]	[0.000]	[0.168]	[0.536]	[0.288]	[0.760]
$\Delta\log(\Delta NC)$	-0.004	-0.004	-0.094	-0.089	-0.075 *	0.038	0.001	-0.047
	[0.912]	[0.933]	[0.265]	[0.102]	[0.072]	[0.382]	[0.963]	[0.052]
$\log(\Delta NC)$	0.011	0.074	0.029	0.073	0.100 *	0.002	-0.001	0.056
	[0.578]	[0.177]	[0.533]	[0.285]	[0.085]	[0.972]	[0.998]	[0.092]
R-squared	0.076	0.050	0.074	0.109	0.101	0.089	0.079	0.046
N	8,859	8,859	8,859	8,859	8,859	8,859	8,859	8,859
individual characteristics	X	X	X	X	X	X	X	X
province FE	X	X	X	X	X	X	X	X
cubic trend (in days)	X	X	X	X	X	X	X	X
average wo mask mandate	0.929	0.755	0.629	0.696	0.777	0.869	0.859	0.796
survey item # (i12_)	health_2	health_3	health_6	health_12	health_13	health_14	health_15	health_20

Notes: The time period is April 2 to August 13, 2020. P-values from wild bootstrap (cgmwildboot) standard errors clustered by province with 5000 repetitions are reported in the square brackets. NC denotes national total cases. The data source is YouGov. The outcome is a dummy which takes value 1 if the respondent answered "Always" or "Frequently" to each survey question in Table C4. Sample weights are used. Individual characteristics include a gender dummy, age dummy (in years), dummies for each household size, dummies for each number of children, and dummies for each employment status. ***, ** and * denote 10%, 5% and 1% significance level respectively.

Table A15: Canada – Closing vs. Re-opening Sub-periods

	Outcome: weekly case growth $\Delta\log(\Delta C)$			
	Closing: March 11 - May 14		Re-opening: May 15 - August 13	
	(1)	(2)	(3)	(4)
Mask_14	n.a.	n.a.	-0.788 *	-0.797 *
	n.a.	n.a.	[0.070]	[0.056]
Business/gathering_14	-0.045	-0.095	-1.115 **	-1.148 *
	[0.914]	[0.874]	[0.038]	[0.056]
School_14	-0.998 ***	-1.041 ***	0.005	-0.016
	[0.000]	[0.000]	[1.000]	[0.939]
Travel_14	-2.433 ***	-2.623 ***	0.910	0.929
	[0.000]	[0.000]	[0.351]	[0.376]
Long-term care_14	-0.803 ***	-0.906 **	-0.260	-0.264
	[0.006]	[0.010]	[0.578]	[0.563]
Behaviour proxy_14	-0.036 *	-0.034	-0.012	-0.013
	[0.087]	[0.139]	[0.841]	[0.834]
$\Delta\log(\Delta C)$_14	0.075	0.076	-0.156	-0.157
	[0.184]	[0.250]	[0.105]	[0.136]
$\log(\Delta C)$_14	-0.399 ***	-0.413 ***	-0.221	-0.221
	[0.000]	[0.000]	[0.148]	[0.161]
$\Delta\log(\Delta NC)$_14		-0.120		-0.346
		[0.535]		[0.709]
$\log(\Delta NC)$_14		0.285		0.494
		[0.312]		[0.657]
$\Delta\log(\Delta T)$	0.110	0.099	0.233	0.261
	[0.256]	[0.299]	[0.479]	[0.423]
R-squared	0.689	0.689	0.169	0.170
N	650	650	910	910
province fixed effects	X	X	X	X
cubic time trend (days)	X	X	X	X

Notes: P-values from wild bootstrap (cgmwildboot) standard errors clustered by province with 5000 repetitions are reported in the square brackets. ***, ** and * denote 10%, 5% and 1% significance level respectively. NC denotes national total cases. No mask mandates are present in the closing period.

Table A16: Canada – Deaths growth (treatment of zero weekly deaths)

	Outcome: weekly deaths growth $\Delta\log(\Delta D)$					
	(1)	(2)	(3)	(4)	(5)	(6)
	baseline		4 largest provinces		population weighted	
Mask_28	-0.922 **	-0.983 **	0.139	0.009	-0.260	-0.480
	[0.022]	[0.032]	[0.762]	[0.762]	[0.592]	[0.488]
Business/gathering_28	-0.134	-0.224	-2.067 ***	-2.277 ***	-1.300	-1.442
	[0.762]	[0.748]	[0.000]	[0.000]	[0.102]	[0.106]
School_28	0.441	0.440	0.599	0.601	0.355	0.371
	[0.317]	[0.341]	[0.381]	[0.255]	[0.500]	[0.557]
Travel_28	-0.005	-0.027	1.645	2.101	0.906	0.741
	[0.972]	[0.935]	[0.259]	[0.244]	[0.216]	[0.405]
Long-term care_28	-0.035	-0.036	-0.024	-0.088	-0.053	-0.056
	[0.900]	[0.900]	[0.878]	[0.762]	[0.896]	[0.808]
Behaviour proxy_28	0.002	0.003	-0.012	-0.001	-0.009	-0.001
	[0.815]	[0.737]	[0.244]	[0.861]	[0.500]	[0.958]
$\Delta\log(\Delta D)$_28	0.141	0.152	-0.037 ***	0.006	0.010	0.065
	[0.361]	[0.345]	[0.000]	[0.599]	[0.818]	[0.344]
$\log(\Delta D)$_28	-0.216 ***	-0.220 ***	-0.139	-0.164	-0.164 *	-0.181
	[0.000]	[0.000]	[0.381]	[0.253]	[0.056]	[0.100]
$\Delta\log(\Delta ND)$_28		-0.121		-0.197		-0.262 *
		[0.476]		[0.244]		[0.065]
$\log(\Delta ND)$_28		0.018		0.203		0.147
		[0.858]		[0.125]		[0.448]
$\Delta\log(\Delta T)$	-0.038	-0.051	0.194 ***	0.125	0.176	0.130
	[0.758]	[0.735]	[0.000]	[0.255]	[0.050]	[0.124]
R-squared	0.251	0.254	0.474	0.480	0.496	0.507
N	1,470	1,470	588	588	1,470	1,470
Province FE	X	X	X	X	X	X
cubic time trend (days)	X	X	X	X	X	X
population weighted	No	No	Yes	Yes	No	No

Notes: The time period is March 11 to August 13, 2020. P-values from wild bootstrap (cgmwildboot) standard errors clustered by province with 5000 repetitions are reported in the square brackets. Columns (1) and (2) repeat columns (3) and (4) from Table 4. Columns (3) and (4) report results from a weighted least squares regression with the province populations used as weights. Columns (5) and (6) restrict the sample to only the largest 4 provinces (BC, ON, QC, and AB) with only 5% (29 out of 588) observations with zero weekly deaths. ***, ** and * denote 10%, 5% and 1% significance level respectively. ND denotes national total deaths.

Table A17: Canada - Correlations between the policy indicators

Policy	indicator	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17
Mask	P1. mandatory indoor masks	1																
	P2. non-essential business/retail	-0.11	1															
	P3. personal services	-0.18	0.67	1														
	P4. restaurants	-0.14	0.64	0.83	1													
Business/	P5. bars/nightclubs	-0.14	0.55	0.75	0.84	1												
gathering	P6. religious worship	-0.05	0.66	0.76	0.80	0.77	1											
	P7. events gathering	-0.07	0.65	0.81	0.84	0.76	0.79	1										
	P8. recreation/parks/gyms	-0.17	0.74	0.78	0.78	0.73	0.75	0.81	1									
	P9. gathering maximum index	-0.02	0.56	0.70	0.72	0.71	0.79	0.76	0.64	1								
School	P10. no school	0.05	0.18	0.27	0.26	0.41	0.27	0.42	0.20	0.51	1							
	P11. travel ban international	0.04	0.16	0.27	0.26	0.43	0.34	0.41	0.16	0.57	0.77	1						
Travel	P12. travel ban domestic	-0.09	0.09	0.07	-0.02	0.14	0.04	-0.01	0.06	0.15	0.15	0.14	1					
	P13. self-isolation international	0.04	0.16	0.27	0.23	0.38	0.30	0.40	0.13	0.53	0.72	0.86	0.15	1				
	P14. self-isolation domestic	-0.14	0.12	0.20	0.07	0.19	0.21	0.06	0.07	0.26	0.24	0.23	0.63	0.23	1			
LTC	P15. LTC visits	-0.16	0.40	0.56	0.58	0.59	0.54	0.57	0.48	0.54	0.35	0.35	0.13	0.32	0.33	1		
	P16. LTC single site	0.05	-0.23	-0.17	-0.08	-0.13	-0.20	-0.05	-0.20	-0.03	0.18	0.25	-0.15	0.26	-0.23	-0.06	1	
	P17. provincial emergency	-0.07	0.21	0.33	0.39	0.56	0.44	0.42	0.30	0.51	0.55	0.63	0.16	0.57	0.26	0.40	0.01	1

Notes: The time period is Feb 26 to July 30 (two weeks before the March 11 - August 13 sample period). Daily province-level data.

Table A18: Canada – Location behaviour and policies

	Outcome: location behaviour							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Retail		Grocery		Workplaces		Behaviour proxy, B_{it}	
Mask	-4.204	-4.175	-0.670	-0.810	-0.385	-0.403	-1.753	-1.796
	[0.440]	[0.429]	[0.814]	[0.770]	[0.806]	[0.795]	[0.563]	[0.514]
Business/gathering	-18.959 *	-14.359 *	-12.243 **	-8.640	-12.110 *	-7.636	-14.437 **	-10.212
	[0.055]	[0.092]	[0.044]	[0.153]	[0.084]	[0.195]	[0.049]	[0.150]
School	-16.524 **	-8.927	-7.111 **	-1.894	-24.795 ***	-17.613 **	-16.143 ***	-9.478
	[0.020]	[0.297]	[0.013]	[0.663]	[0.004]	[0.028]	[0.003]	[0.114]
Travel	-15.648	-10.505	-18.913 ***	-13.735 **	-7.354	-2.029	-13.971 *	-8.756
	[0.162]	[0.340]	[0.000]	[0.019]	[0.174]	[0.607]	[0.058]	[0.223]
Long-term care	0.131	-0.717	-0.237	-1.088	-1.987	-2.864 *	-0.698	-1.556
	[0.980]	[0.914]	[0.960]	[0.768]	[0.480]	[0.079]	[0.873]	[0.610]
$\Delta\log(\Delta C)$	1.614 **	1.235 *	1.905 ***	1.397 ***	1.134 *	0.707	1.551 ***	1.113 **
	[0.023]	[0.051]	[0.000]	[0.004]	[0.075]	[0.132]	[0.004]	[0.034]
$\log(\Delta C)$	-2.545 ***	-2.062 ***	-1.935 ***	-1.537 ***	-1.387 **	-0.912 *	-1.956 ***	-1.504 ***
	[0.005]	[0.000]	[0.007]	[0.006]	[0.013]	[0.075]	[0.007]	[0.000]
$\Delta\log(\Delta NC)$		5.462 **		8.543 ***		6.511 ***		6.839 ***
		[0.034]		[0.000]		[0.000]		[0.000]
$\log(\Delta NC)$		-9.372 ***		-7.206 **		-9.076 ***		-8.551 ***
		[0.004]		[0.018]		[0.000]		[0.000]
R-squared	0.935	0.942	0.866	0.880	0.910	0.925	0.927	0.938
N	1,560	1,560	1,560	1,560	1,560	1,560	1,560	1,560
province fixed effects	X	X	X	X	X	X	X	X
cubic time trend (days)	X	X	X	X	X	X	X	X

Notes: The time period is March 11 to August 13, 2020. P-values from wild bootstrap (cgmwildboot) standard errors clustered by province with 5000 repetitions are reported in the square brackets. The behaviour proxy B_{it} in columns (7) and (8) is the unweighted average of the "retail", "grocery" and "workplaces" Google mobility indices. ***, ** and * denote 10%, 5% and 1% significance level respectively. NC denotes national total cases.

Table A19: Ontario – Policies and information only

	Outcome: weekly case growth $\Delta\log(\Delta C)$					
	(1)	(2)	(3)	(4)	(5)	(6)
	no time trend		cubic time trend		week fixed effects	
Mask_14	-0.228 *	-0.286 **	-0.333 **	-0.341 **	-0.286 **	-0.298 **
	[0.050]	[0.036]	[0.025]	[0.025]	[0.036]	[0.028]
Business/gathering_14	0.041	0.132	0.039	0.512	0.128	0.256
	[0.816]	[0.710]	[0.937]	[0.437]	[0.824]	[0.670]
Long-term care_14	0.467	0.366	0.799	-0.240	-1.022	-2.033 *
	[0.570]	[0.670]	[0.653]	[0.856]	[0.393]	[0.099]
$\Delta\log(\Delta C)$_14	0.028	0.026	0.027	0.030	0.014	0.014
	[0.645]	[0.682]	[0.676]	[0.652]	[0.804]	[0.825]
$\log(\Delta C)$_14	-0.198 ***	-0.202 ***	-0.200 ***	-0.207 ***	-0.195 ***	-0.198 ***
	[0.002]	[0.001]	[0.001]	[0.000]	[0.001]	[0.001]
$\Delta\log(\Delta PC)$_14		0.391		0.260		0.572 **
		[0.170]		[0.401]		[0.038]
$\log(\Delta PC)$_14		-0.045		0.462		0.128
		[0.841]		[0.168]		[0.712]
$\Delta\log(\Delta T)$	-0.363 **	-0.481 **	-0.209	-0.343	-0.194	-0.464
	[0.050]	[0.028]	[0.381]	[0.169]	[0.564]	[0.144]
R-squared	0.046	0.050	0.051	0.058	0.091	0.094
N	3,094	3,094	3,094	3,094	3,094	3,094
public health unit FE	X	X	X	X	X	X
cubic time trend (days)			X	X		
week fixed effects					X	X

Notes: The time period is May 15 to August 13, 2020. P-values from wild bootstrap (cgmwildboot) standard errors clustered by public health unit (PHU) with 5000 repetitions are reported in the square brackets. ***, ** and * denote 10%, 5% and 1% significance level respectively.

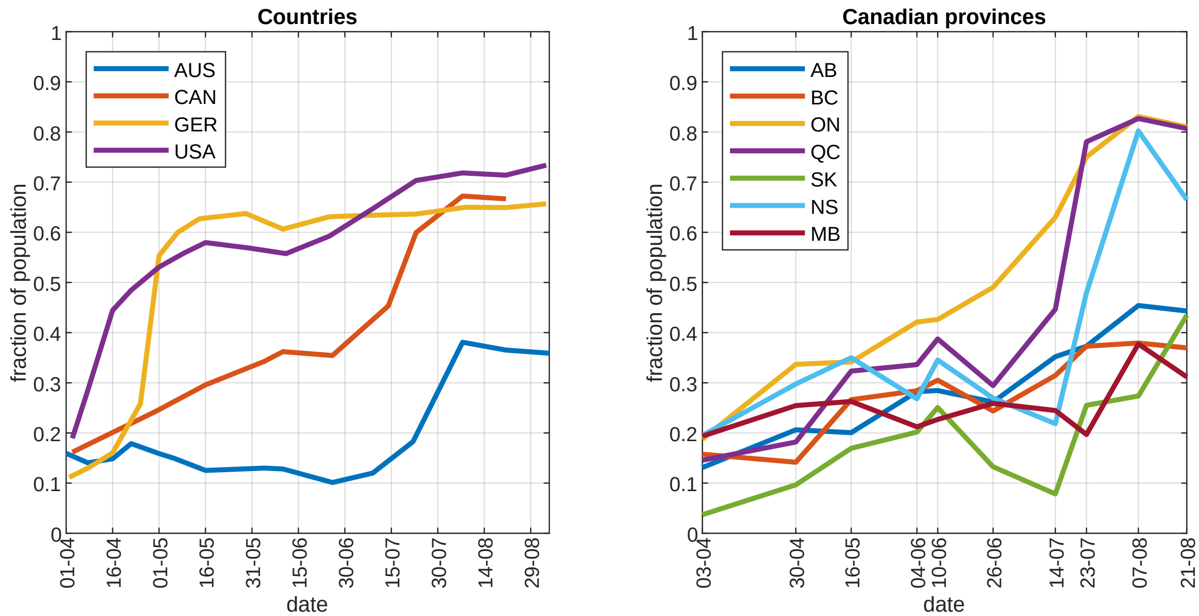
Table A20: Canada – Policy and Information only

	Outcome: weekly case growth, $\Delta\log(\Delta C)$					
	(1)	(2)	(3)	(4)	(5)	(6)
	no time trend		cubic time trend		week fixed effects	
Mask_14	-0.413 ***	-0.416 ***	-0.629 ***	-0.618 ***	-0.567 ***	-0.561 ***
	[0.000]	[0.000]	[0.000]	[0.002]	[0.000]	[0.004]
Business /gathering_14	-0.288	-0.425	-0.665	-0.716 **	-0.500	-0.579
	[0.112]	[0.165]	[0.103]	[0.032]	[0.138]	[0.112]
School_14	-0.244	-0.381	-0.431	-0.443 *	-0.250	-0.353
	[0.461]	[0.334]	[0.144]	[0.066]	[0.258]	[0.137]
Travel_14	-0.509	-0.794	-0.293	-0.368	-0.430	-0.592
	[0.270]	[0.106]	[0.579]	[0.580]	[0.612]	[0.481]
Long-term care_14	-0.100	-0.193	0.027	0.037	0.081	0.064
	[0.67]	[0.494]	[0.917]	[0.904]	[0.805]	[0.849]
$\Delta\log(\Delta C)$_14	-0.024	-0.010	-0.040	-0.026	-0.017	-0.015
	[0.56]	[0.824]	[0.385]	[0.555]	[0.772]	[0.797]
$\log(\Delta C)$_14	-0.182 ***	-0.208 ***	-0.197 ***	-0.200 **	-0.201 *	-0.214 *
	[0.000]	[0.000]	[0.000]	[0.01]	[0.064]	[0.067]
$\Delta\log(\Delta NC)$_14		-0.073		-0.221		-0.106
		[0.636]		[0.291]		[0.581]
$\log(\Delta NC)$_14		0.121		0.012		0.281 *
		[0.359]		[0.938]		[0.090]
$\Delta\log(\Delta T)$	0.139	0.187 *	0.185 *	0.176 *	0.155	0.162 *
	[0.107]	[0.052]	[0.069]	[0.080]	[0.131]	[0.100]
R-squared	0.382	0.386	0.391	0.393	0.414	0.416
N	1,560	1,560	1,560	1,560	1,560	1,560
province fixed effects	X	X	X	X	X	X
cubic time trend (days)			X	X		
week fixed effects					X	X

Notes: The time period is March 11 to August 13, 2020. P-values from wild bootstrap (cgmwildboot) standard errors clustered by province with 5000 repetitions are reported in the square brackets. ***, ** and * denote 10%, 5% and 1% significance level respectively.

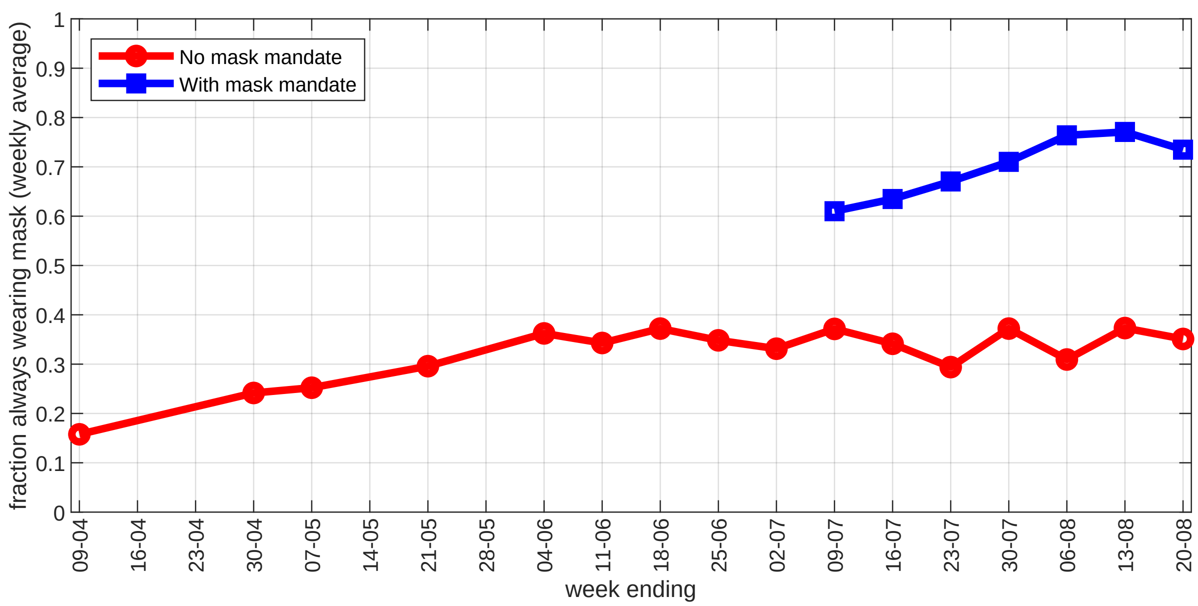
Appendix B. Additional Figures

Figure B1: Self-reported mask usage in selected countries and Canadian provinces



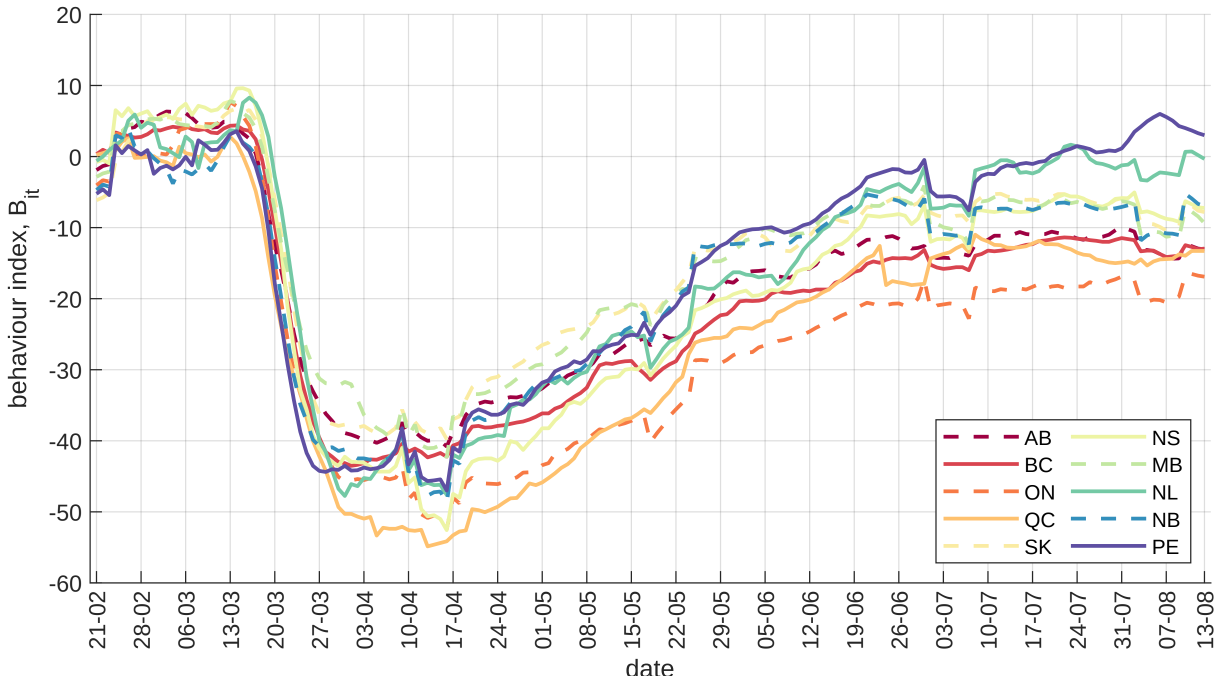
Notes: The data source is YouGov. The outcome equals 1 if the respondent answered "Always" to the question "Worn a face mask outside your home" and 0 otherwise. The sample weights are used to construct the country and provincial averages.

Figure B2: Canada - mask mandates and self-reported mask usage



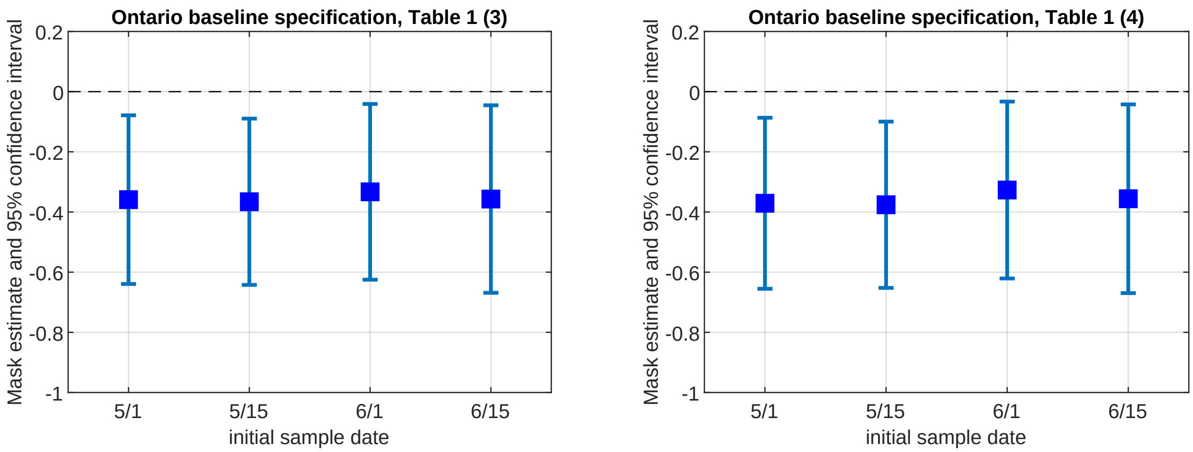
Notes: The data source is YouGov. The figure plots the average self-reported mask usage by week (the fraction of respondents who answered "Always" to the survey question "Worn a face mask outside your home") in the provinces with vs. without mask mandates. Sample weights used to compute the averages.

Figure B3: Canada - Behaviour proxy, B_{it}



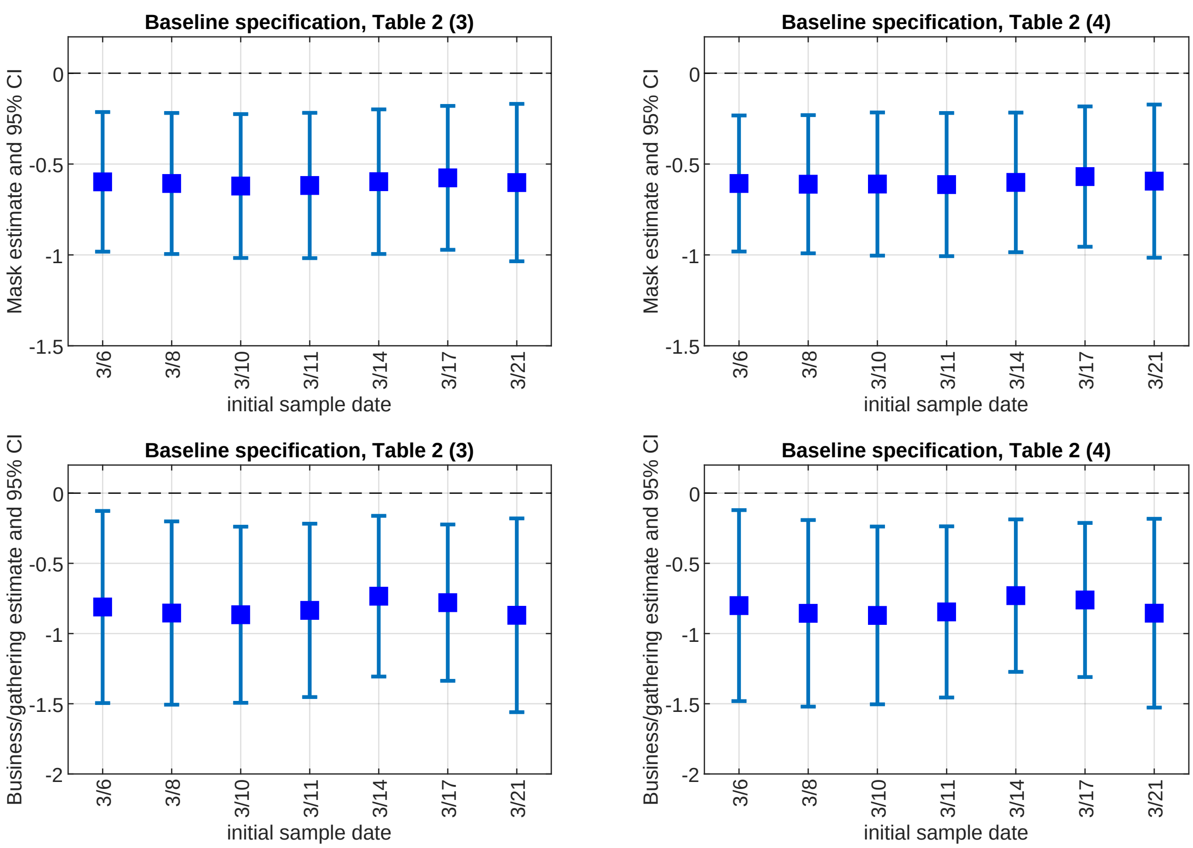
Notes: The Behaviour proxy B_{it} is the average of the "retail", "grocery and pharmacy", and "workplaces" Google mobility indicators. Province-level 7-day moving averages are plotted.

Figure B4: Ontario - different initial dates



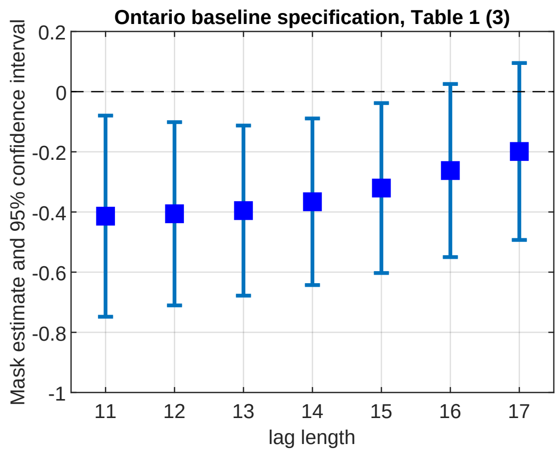
Notes: We plot the coefficient estimates on mask policy, with 95% confidence intervals, from equation (1), for different initial dates of the sample. The initial sample date in the baseline specifications reported in Table 1 is May 15. The left panel corresponds to baseline column (3) in Table 1, the right column corresponds to column (4) in Table 1.

Figure B5: Canada - different initial dates



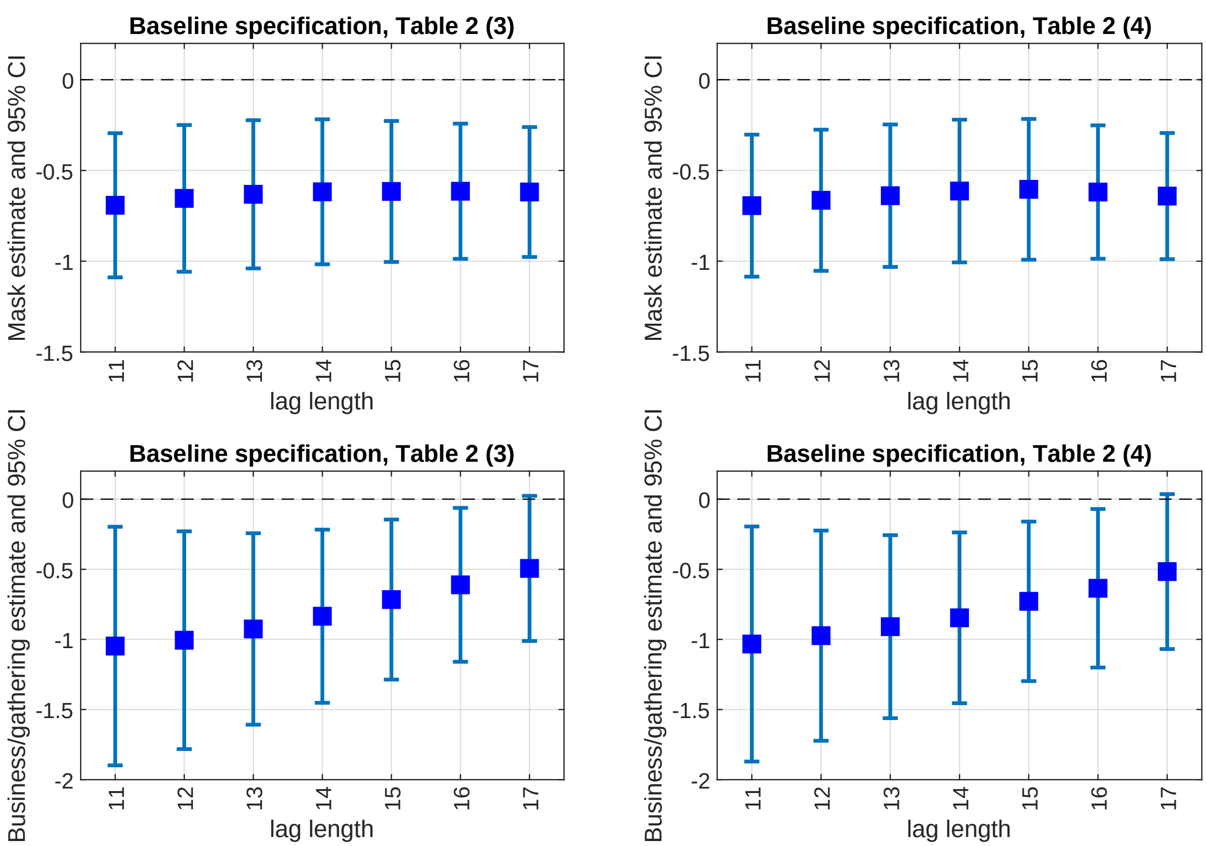
Notes: We plot the coefficient estimates on mask policy, with 95% confidence intervals, in the upper panel and the estimates on business/gathering policy in the lower panel, from equation (1) for different initial dates of the sample. The initial date in our baseline specification (Table 2) is March 11. The left panels correspond to column (3) in Table 2; the right panels correspond to column (4) in Table 2.

Figure B6: Ontario - different lags



Notes: We plot the coefficient estimates on mask policy, with 95% confidence intervals, in equation (1) for different lag values. The lag used in the baseline specifications in Table 1 is 14 days. The left panel corresponds to column (3) in Table 1, the right column corresponds to column (4) in Table 1.

Figure B7: Canada - different lags



Notes: We plot the estimates on mask policy in the upper panel and the business/gathering policy in the lower panel, in equation (1) for different lag values. The lag in our baseline specification (Table 2) is 14 days. The left panels correspond to column (3) in Table 2; the right panels correspond to column (4) in Table 2.

Figure B8: Canada – Weekly cases, deaths and tests (growth rate)

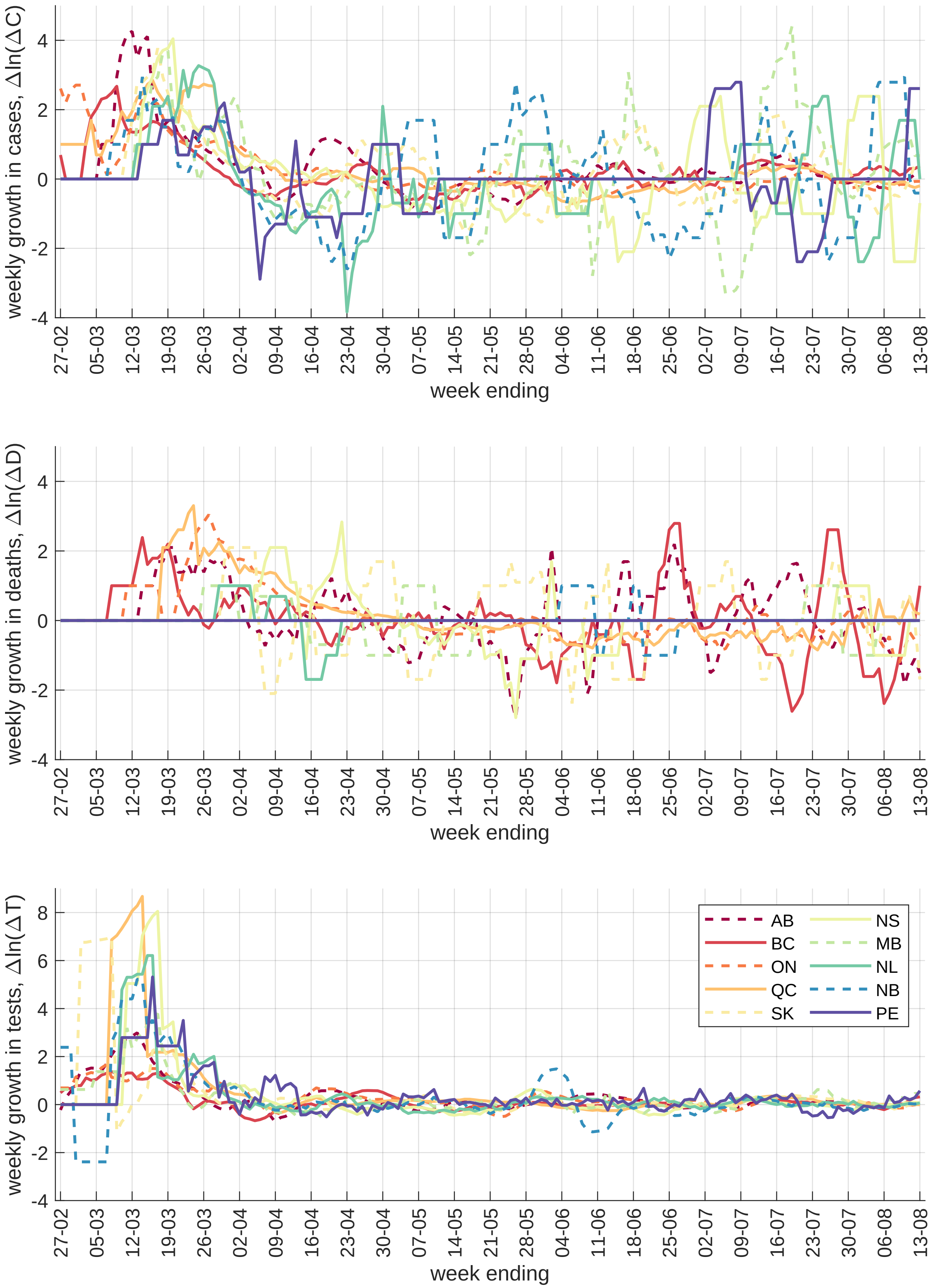


Figure B9: Canada – Weekly cases, deaths and tests (level)

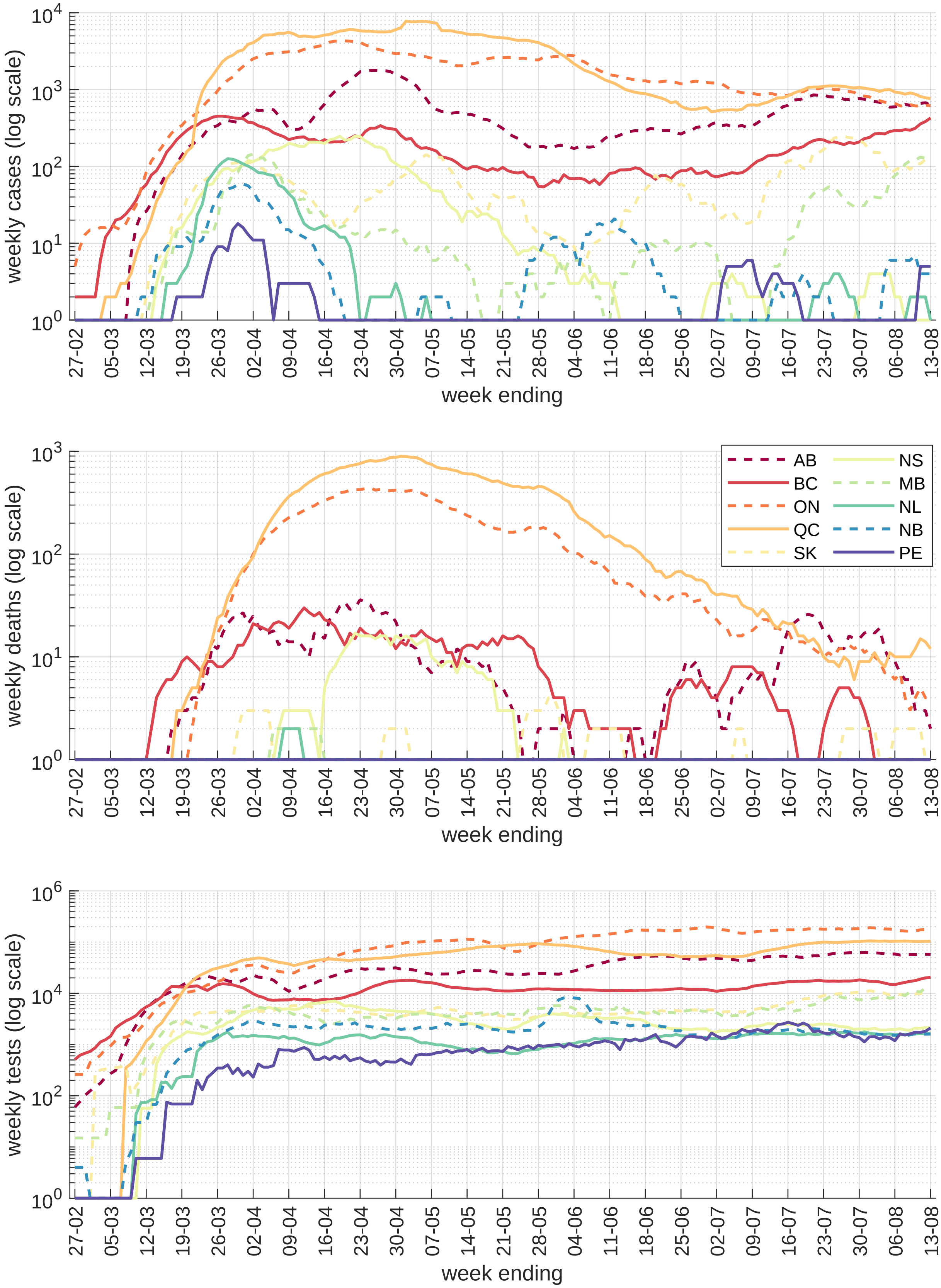


Figure B10: Canada – Daily cases, deaths and tests

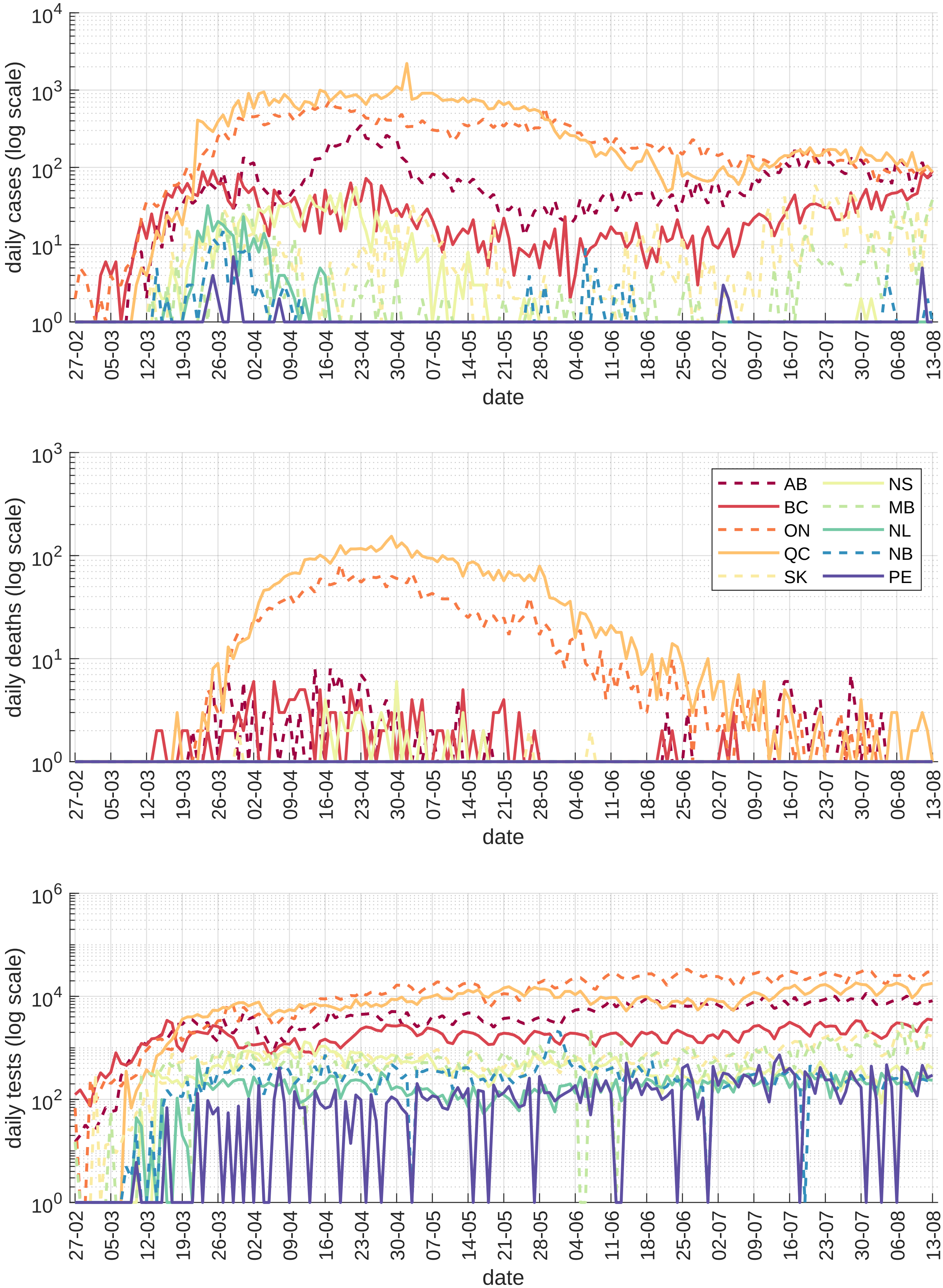
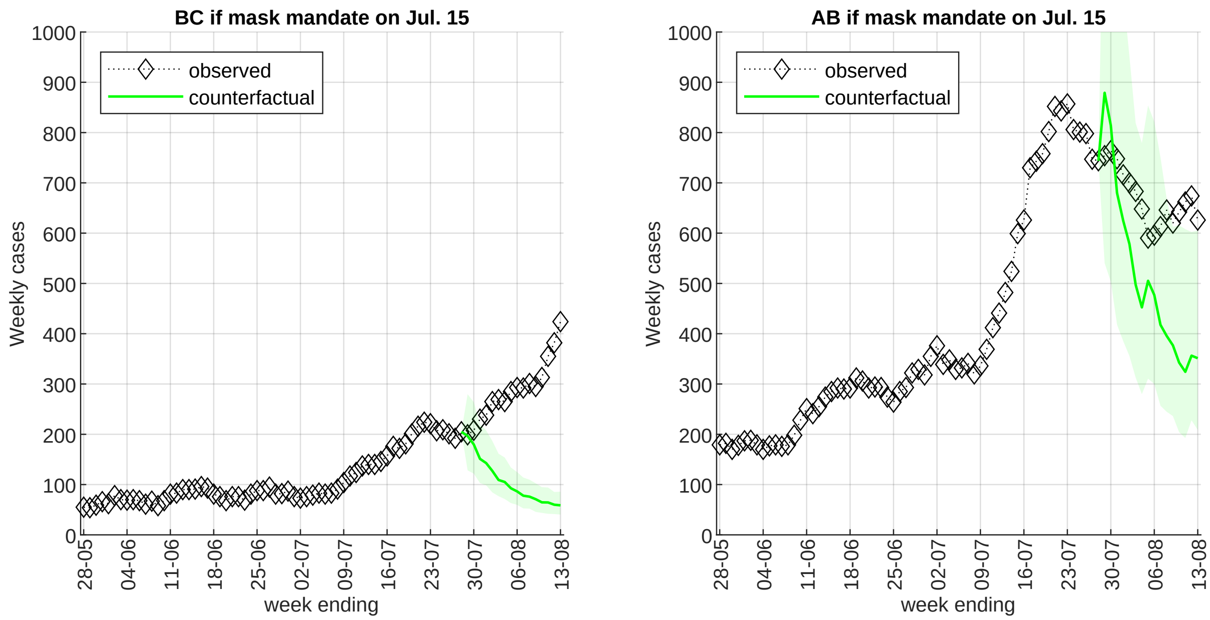
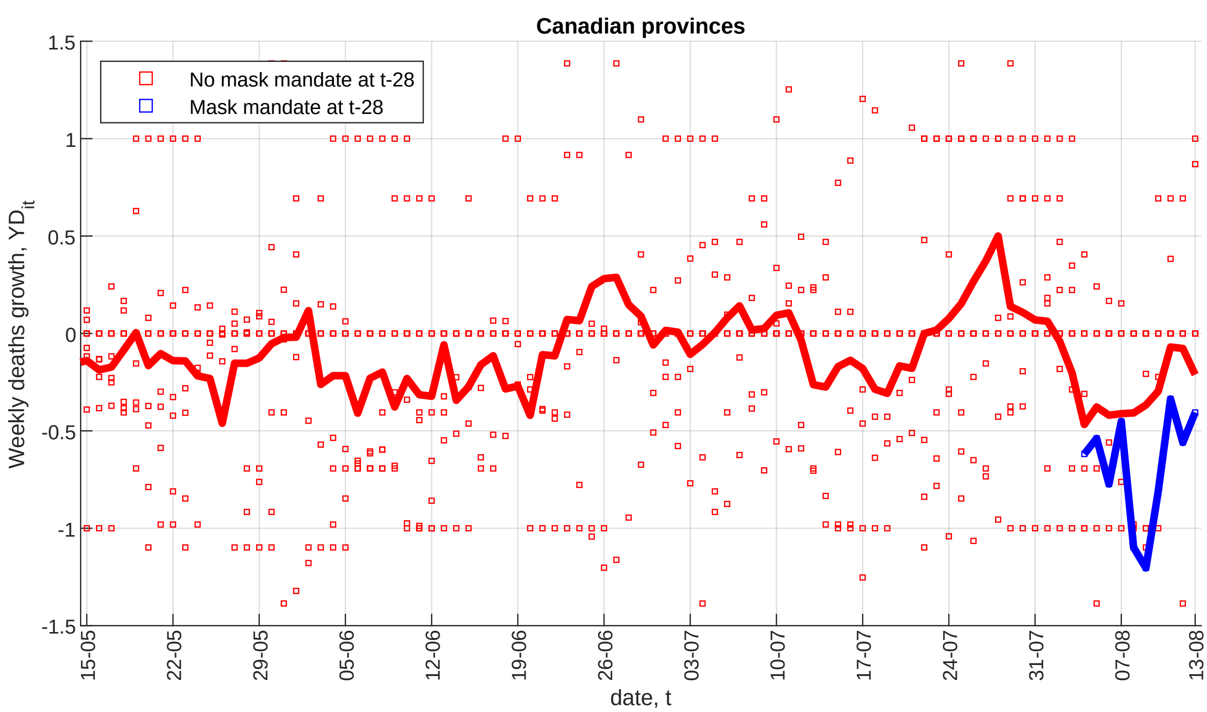


Figure B11: Counterfactuals – Mask mandates in Alberta and British Columbia



Notes: The figure assumes mask adoption on July 15 for two provinces that have not yet adopted mask mandates, specifically British Columbia (BC, left panel) and Alberta (AB, right panel). The counterfactual uses the mask mandate estimate -0.613 from Table 2, column (4).

Figure B12: Canada - mask mandates and weekly deaths growth



Notes: Average log weekly death growth in provinces with vs. without mask mandates 28 days prior.

Appendix C. Definitions and data sources

Table C1: Policy indicators and aggregates

Non-Essential Travel	
restrictions - international	1: travelers that are neither citizens nor residents 0.5: same as 1, but US citizens allowed
restrictions - inter-provincial	1: residents of all other provinces 0.5: residents of some other provinces
self-isolation - international	1: required (by provincial or federal government) 0.5: recommended (by provincial or federal government)
self-isolation - inter-provincial	1: required of residents of all other provinces 0.5: required of residents of some other provinces, or recommended
Primary and Secondary Schools	
schools closed	1: no classes (includes Spring and Summer breaks) 0.5: part-time classes; 0: classes in session
Business and Gathering Regulations	
non-essential and retail business personal services business restaurants bars and nightclubs places of worship events and gatherings recreation, gyms and parks	0: no or lowest restrictions; 1: strictest restrictions; values between 0 and 1: partial restrictions
indoor gatherings maximum	1: no gathering allowed; $x \in [0.5, 1]$: limit of $100(1 - x)$ $x \in [0, 0.5]$: limit of $25/x$
Long-Term Care (LTC) Regulations	
visiting restrictions	1: no visits (with limited exceptions such as end of life) 0.5: number of visitors restricted
single-site work requirement[1]	1: requirement in effect 0.5: requirement with explicit later implementation deadline
Mandatory Masks	
indoor public places[2]	1: mask mandate in effect; 0: no mandate
provincial declaration of emergency	1: in effect; 0: not in effect

Notes: 1. We do not consider recommendations or requirements limited to outbreak facilities. 2. We do not consider limited mask mandates such as applying only to transit or personal service establishments.

Table C2: Ontario public health regions and date of mask mandate

1	Algoma Public Health Unit	July 17, 2020
2	Brant County Health Unit	July 20, 2020
3	Chatham-Kent Health Unit	August 14, 2020
4	Durham Region Health Department	July 10, 2020
5	Eastern Ontario Health Unit	July 07, 2020
6	Grey Bruce Health Unit	July 17, 2020
7	Haldimand-Norfolk Health Unit	August 01, 2020
8	Haliburton, Kawartha, Pine Ridge District Health Unit	July 13, 2020
9	Halton Region Health Department	July 22, 2020
10	Hamilton Public Health Services	July 20, 2020
11	Hastings and Prince Edward Counties Health Unit	July 10, 2020
12	Huron Perth District Health Unit	July 17, 2020
13	Kingston, Frontenac and Lennox & Addington Public Health	June 27, 2020
14	Lambton Public Health	July 31, 2020*
15	Leeds, Grenville and Lanark District Health Unit	July 07, 2020
16	Middlesex-London Health Unit	July 18, 2020
17	Niagara Region Public Health Department	July 31, 2020
18	North Bay Parry Sound District Health Unit	July 24, 2020
19	Northwestern Health Unit	August 17, 2020
20	Ottawa Public Health	July 07, 2020
21	Peel Public Health	July 10, 2020
22	Peterborough Public Health	August 01, 2020
23	Porcupine Health Unit	July 23, 2020
24	Region of Waterloo, Public Health	July 13, 2020
25	Renfrew County and District Health Unit	July 14, 2020
26	Simcoe Muskoka District Health Unit	July 13, 2020
27	Southwestern Public Health	July 31, 2020
28	Sudbury & District Health Unit	July 17, 2020
29	Thunder Bay District Health Unit	July 24, 2020
30	Timiskaming Health Unit	July 24, 2020
31	Toronto Public Health	July 07, 2020
32	Wellington-Dufferin-Guelph Public Health	June 12, 2020
33	Windsor-Essex County Health Unit	June 26, 2020
34	York Region Public Health Services	July 17, 2020

*Lambton Public Health did not enact a mask mandate as of the end of August 2020. However, the City of Sarnia, which has 58 % of Lambton's population according to the 2016 Census, enacted a mask mandate on July 31, 2020. The mask variable for Lambton is coded as 0.5 from July 31, 2020 onward.

Table C3: Canada COVID-19 official data sources

Province	Cases	Deaths	Tests
Alberta (AB)	link	link	link
British Columbia (BC)	link	link	link
Ontario (ON)	link	link	link
Quebec (QC)	link	link	link
Saskatchewan (SK)	link[1]	link	link
Nova Scotia (NS)	link	link	link
Manitoba (MB)	link	link	link[2]
Newfoundland and Labrador (NL)	link[1]	link	link
New Brunswick (NB)	link	link	link
Prince Edward Island (PE)	link	link	link

Notes: 1. Saskatchewan and Newfoundland and Labrador do not revise their posted data series. We made data adjustments based on subsequent revisions announced in government bulletins; 2. The Manitoba tests numbers were manually collected from the COVID-19 provincial government bulletins.

Weather – we downloaded historical weather data for the largest city in each province from the Weather Canada website. The data provide daily information on 11 variables: maximum temperature (C), minimum temperature (C), mean temperature (C), heating degree-days, cooling degree-days, total rain (mm), total snow (cm), total precipitation (mm), snow on the ground (cm), direction of maximum wind gust (tens of degrees), and speed of maximum wind gust (km/h). We only use the temperature and precipitation data in Table A11 as possible factors determining outside vs. inside activity.

News – we collected data from *Proquest Canadian Newsstream*, a subscription service to all major and small-market daily or weekly Canadian news sources. We recorded the number of search results for each day from Feb 1, 2020 to Aug 20, 2020 by searching the database for the keywords “Coronavirus” or “COVID-19”. We only counted the results with source listed as “newspaper” since other sources, such as blogs or podcasts, tend to duplicate the same original content.

Table C4: YouGov Survey Questions

Survey item	Question
i12_health_2	Washed hands with soap and water
i12_health_3	Used hand sanitiser
i12_health_6	Avoided going out in general
i12_health_12	Avoided small social gatherings (not more than 2 people)
i12_health_13	Avoided medium-sized social gatherings (between 3 and 10 people)
i12_health_14	Avoided large-sized social gatherings (more than 10 people)
i12_health_15	Avoided crowded areas
i12_health_20	Avoided touching objects in public (e.g. elevator buttons or doors)

Notes: the data source is YouGov. Possible responses to each survey item are ”Always”, ”Frequently”, ”Sometimes”, ”Rarely”, and ”Not at all”. For Table A13, we create a binary variable taking value 1 if the response is ”Always” and 0 otherwise. For Table A14, we create a binary variable taking value of 1 if the respondent answered either ”Always” or ”Frequently” and 0 otherwise.

All data used in the paper are available at https://github.com/C19-SFU-Econ/data.

Appendix D. Lags Determination

As discussed in Section 3.1, we assume a lag of 14 days between a change in policy or behaviour and its hypothesized effect on weekly case growth, and a lag of 28 days between such a change and its effect on weekly death growth.

First, we consider the lag between infection and a case being reported. As most identified cases of COVID-19 in Canada are symptomatic, we focus on symptomatic individuals. For most provinces cases are listed according to the date of report to public health. In provinces where the dates instead refer to the public announcement, we shifted them back by one day, as announcements typically contain the cases reported to public health on the previous day. The relevant lag therefore has two components:

1. Incubation period: Most studies suggest an average incubation period of 5-6 days (e.g. 5.2 days in Li et al. (2020), 5.5 days in Lauer et al. (2020), 5.6 days in Linton et al. (2020), 6.4 days in Backer et al. (2020)).

2. Time between symptoms onset and reporting of the case to public health: the Ontario data contain an estimate of the symptom onset date (”episode date”) for each case. For our sample period the average difference between the date of report and the episode date is 4.8 days (median: 4 days) including only values from 1 to 14 days, and 6.3

days (median: 5 days) including only values from 2 to 28 days. We assume that the lags in Ontario and in other provinces are similar, and use a value of 5-6 days between symptom onset and report to public health authorities.

Adding these together implies that the typical lag between infection and a positive case being reported to public health is around 11 days.

Second, we consider the effect of weekly averaging on the appropriate lag for our analysis. Suppose a policy or behavioural change starts on date t, impacting the daily growth in infections between dates $t-1$ and t and in each subsequent day. Then, assuming a lag of 11 days between infection and case reporting, case counts C are affected from date $t+11$ onward. Our outcome variable $\Delta \log(\Delta \mathrm{C})$ thus would react to the original policy or behavioral change on date $t + 11$. The change is complete on $t + 23$, when the week from $t + 17$ to $t + 23$ is compared to the week from $t + 10$ to $t + 16$. The midpoint of the change is $t + 17$.

Choosing a lag of l days implies that the policy/behaviour variable phases in from $t + l$ to $t + l + 6$. To match the midpoint of this phase-in to the midpoint of the change in the outcome variable, we set $l = 14$. The chosen lag matches the lag used by other authors who study COVID-19 policy interventions, e.g., CKS (2020). We explore sensitivity to alternative lags in Section 4.3.

With respect to deaths, our data are, in most cases, backdated (revised by the authorities ex-post) to the actual date of death. The medical literature suggests that the mean time from symptom onset to death is around 19 days (20 days in Wu et al. (2020), 17.8 days in Verity et al. (2020), 20.2 days when accounting for right truncation in Linton et al. (2020), 16.1 days in Sanche et al. (2020), etc.), that is, two weeks longer than our estimate of the time from symptom onset to reporting of a positive test result. We correspondingly set the lag used in our analysis of the death growth rate (Section 4.5) to 28 days.