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 behavioural responses using Google mobility data. Our identification strategy exploits variation in the timing of indoor face mask mandates staggered over two months in the 34 public health districts in Ontario, Canada's most populous province. We find that mask mandates are associated with a 25 percent or larger weekly reduction in new COVID-19 cases in July and August, relative to the trend in absence of mask mandate. 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 number of new cases in Canada by 25 to 40 percent in mid-August, which corresponds to 700 to 1,100 fewer cases per week.

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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 came from research on 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, doubts regarding the usefulness of specific policy measures may persist because of uncertainty regarding adherence to the rules and other behavioural responses. For example, even though there is significant agreement in the medical literature that respiratory transmission of COVID-19 is the dominant vector (Meyerowitz et al., 2020), and many clinical studies have shown that face masks reduce the transmission of COVID-19 and similar diseases (Chu et al. 2020, Prather et al. 2020, Leung et al. 2020, Greenhalgh et al. 2020), a 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.

The relatively low economic cost of mask mandates relative to other COVID-19 containment measures has generated keen interest worldwide for studying their effectiveness. This interest has been compounded by the substantial variation in official advice regarding mask use, with national health authorities and the World Health Organization giving inconsistent or contradictory recommendations over time, ranging from 'not recommended' to 'mandatory'. 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]

An added challenge is to disentangle the impact of mask mandates from that of other policies, behavioural responses, or third factors (Chernozhukov et al. 2020, Mitze et al. 2020). Given the absence of large-scale randomised controlled trials on mask mandates (Howard et al., 2020), observational studies like ours are essential for informing health policy and public opinion, by formally analyzing the relationship between the various policy measures and the rate of propagation of COVID-19.

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. The Canadian data have the important advantage of allowing two complementary approaches to address

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

our objective. First, we estimate the effect of mask mandates by exploiting within-province geographic variation in the timing of indoor face mask mandates in the 34 public health regions (PHUs) in Ontario, Canada's most populous province with roughly 40% (15 mln) of the country's population (Statistics Canada, 2020). The advantage of this approach is that it uses variation over a relatively small geographic scale (PHU), holding all province-level policies and factors constant. The adoption of indoor face mask mandates in the 34 sub-regions was staggered over approximately two months, creating sufficient intertemporal policy variation.

Second, we evaluate the impact of NPIs in Canada as a whole, using the variation in the timing of policies in the country's ten provinces. By studying inter-provincial variation in the COVID-19 policy measures, we can analyze the impact of not only mask mandates, but also other NPIs, for which there is little or no variation across Ontario's PHUs, including regulations on businesses and gatherings, schooling, travel and long-term care. In addition, the 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 behavioural changes. Our empirical approach also allows past epidemiological outcomes to impact current outcomes, as information variables affecting unmeasured behaviour and policy, or directly, as in the SIR model framework.

We find that, two weeks after implementation, mask mandates are associated, on average, with a reduction of 29 to 37 log points in the weekly case growth rate, which can be interpreted as a 25 to 31% weekly reduction in new diagnosed COVID-19 cases in Ontario, relative to the trend in absence of mask mandate. We find corroborating evidence in the province-level analysis, with a 36 to 46% weekly reduction in cases relative to the no-mandate trend, depending on the empirical specification. Furthermore, using additional survey data (Jones et al. 2020), we show that mask mandates increased self-reported mask usage in Canada by 30 percentage points shortly after implementation, suggesting that the policy has a significant impact on behaviour. Jointly, our results suggest that mandating mask wearing in indoor public places can be a powerful policy tool to slow the spread of COVID-19, with little associated economic disruption at least in the short run.[2]

[2]Hatzius et al. (2020) estimate that a national mask mandate in the USA could replace alternative

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

In addition, we find that the most stringent policy restrictions on businesses and gatherings observed in the data are associated with a weekly decrease of 48 to 57% in new cases (65 to 85 log point reduction in the case growth rate), relative to absence 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 closing period (March-April). Our results on business/gathering regulations and school closures suggest that relaxed restrictions and the associated increase in business or workplace activity and gatherings (including retail, restaurants and bars) or school re-opening can offset in magnitude, in whole or in part, the estimated effect of mask mandates on COVID-19 case growth, both in our sample and subsequently.

A further contribution of this research is that we assemble, from official sources only, and make publicly available a complete data set of COVID-19 cases, deaths, tests and policy measures in all 10 Canadian provinces.[3] Specifically, we constructed, from 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 other recent empirical studies 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 broadly 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 point reduction in the weekly growth rate of cases. This is substantially smaller that our estimates, possibly because the mask mandates that we study

restrictions costing 5% of GDP.

[3]All data are available for download at github.com/C19-SFU-Econ/data. The COVID-19 cases, deaths and tests data that we collected and use 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.

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 studies. First, we exploit both regional variation within the same province (like Mitze et al., 2020 but without synthetic controls) and provincial variation in the whole country (like CKS, 2020) and find similar results, which strengthens the validity of our findings. Second, we additionally show that self-reported mask usage has increased after introducing mask mandates. We view this "first-stage" result on mask usage as informative, since the effectiveness of any NPI or public policy critically depends on the compliance rate. Moreover, this result mitigates possible concerns that the large estimated mask mandate effect on COVID-19 case growth may be caused by factors other than the mask policy. Third, an important 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 also 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) study the effectiveness of universal adoption of homemade cloth face masks and conclude that it 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 and countries without such norms.[6]

In the medical literature, Prather et al. (2020) conclude 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 mask usage 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

[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 (S. Korea, Japan, Hong Kong and Taiwan). On a weekly basis, this is a difference of 49 log points $(100(\log(1.18^7) - \log(1.1^7)))$ in case growth.

breath and coughs of children and adults with acute respiratory illness and find 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), a recent comprehensive review of the evidence on COVID-19 transmission, conclude that there is strong evidence, from case and cluster reports, 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.[7] Mohammed et al. (2020) use 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 that trust in public health officials remained consistent over time. Yuksel et al. (2020) use an outcome variable constructed from Apple mobility data along with weather data and lagged COVID-19 cases or deaths as dependent variables to study compliance with social distancing measures.[8]

2 Data

We use three main data sources, respectively for epidemiological variables, NPI and mask mandates, and behavioural 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 data set of COVID-19 cases, deaths, tests and policy measures in all ten Canadian provinces.[9] 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 files shared at the project's Github repository.

Implementation dates of NPIs and other public policies were collected from government websites, announcements, public health orders and staged re-opening plans, collected from

[7] Several papers study the effect of COVID-19 policies elsewhere or around the world. See, e.g., Hsiang et al. (2020), Dergiades et al. (2020), Abouk and Heydari (2020).

[8] See also Armstrong et al. (2020), who find strong evidence of policy measures on subsequent mobility behaviour in 75 US and Canadian cities.

[9] 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.

the respective 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.[10] 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 behavioural 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 period January 3 to February 6, 2020.[11] In Ontario, these location data are available for each of the 51 first-level administrative divisions (counties, regional municipalities, single-tier municipalities and districts).[12]

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 behavioural 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.

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

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

[12]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.

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 health region (PHU) for the Ontario analysis and province for the national analysis, and t denotes time measured in days.

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

2. 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 regulations on businesses and gatherings) by PHU and date.

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

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

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 behavioural responses on COVID-19 outcomes, we estimate the following equation:

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

where l denotes a time lag measured in days. Equation (1) models the relationship between COVID-19 outcomes, Y_{it} and lagged policy measures, P_{it-l}, lagged behaviour, B_{it-l}, and information (lagged outcomes), I_{it}. For case growth as the outcome, we use a 14-day lag, $l = 14$. For deaths growth as the outcome, we use $l = 28$.[13] The choice of these lags is discussed in detail in Appendix D, and alternative lags are explored in Section 4.3.

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 about the level or growth rate of cases or deaths. Also, past cases may be correlated with (lagged) government policies or behaviours that may not be fully captured by the included policy and behaviour variables.

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

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 behavioural proxy measure (see Table A18).

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 geo-location trends proxy, B_{it-l}. In Appendix Tables A19 and A20, we also report estimates of equation (1) without including the behavioural 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 behavioural proxy B_{it-l} are very similar to those from estimating equation (1).

3.2 Data variables and descriptive analysis

Outcomes. Our main outcome of interest is the weekly growth rate of new positive COVID-19 cases as defined below.[14] We use weekly outcome data to correct for the strong day-of-the-week effect present in COVID-19 data.[15] 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 (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 (log) weekly case growth rate, Y_{it} 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.[16] The weekly death

[14] We also report results using the growth rate of deaths as supplementary analysis in Section 4.6.

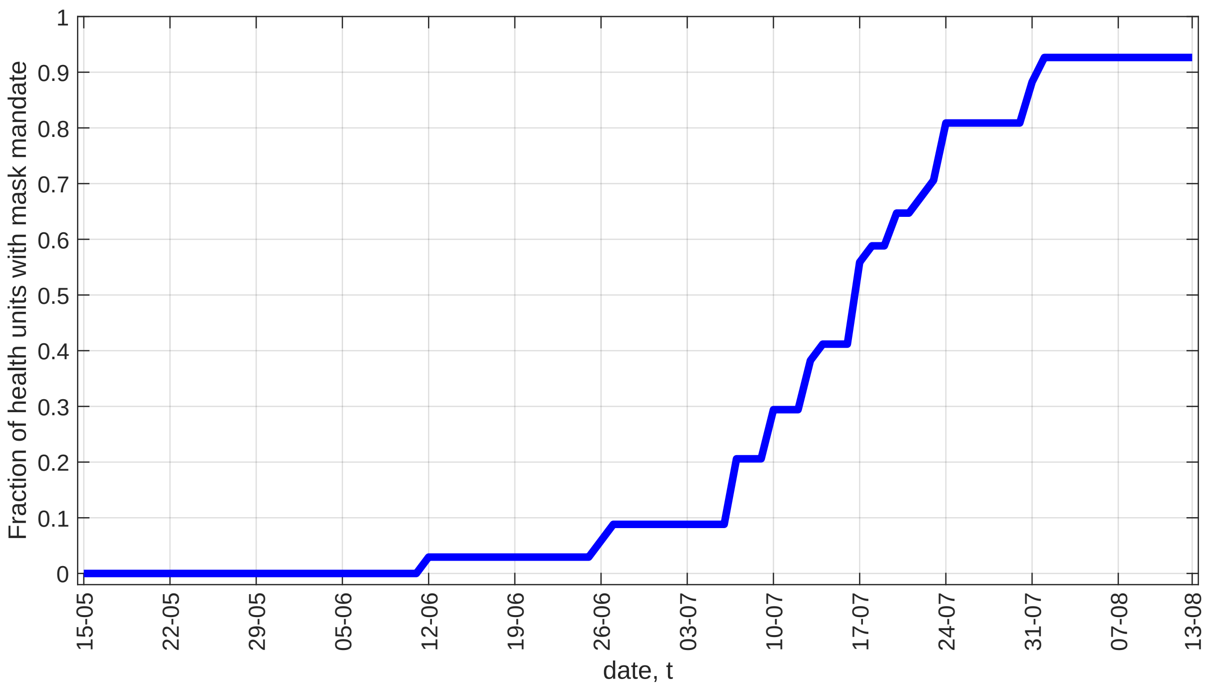
[15] Figures B9 and B10 in the Appendix respectively display the weekly and daily cases, deaths and tests in each Canadian province over time. There are markedly lower numbers reported on weekends or holidays.

[16] 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

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 in the 34 PHUs. 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.[17]

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 17 policy indicators listed in Table C1 in Appendix C. The values are on the interval [0,1], with 0 meaning absence 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 Table C1 for more details and definitions) or geographical coverage (in large provinces). The numerical

logs, by replacing log(0) with 0, and by using population weighted least squares; see Tables A5 and A8.

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

values are assigned at the daily level for each region (PHU or province), while maintaining comparability across regions.

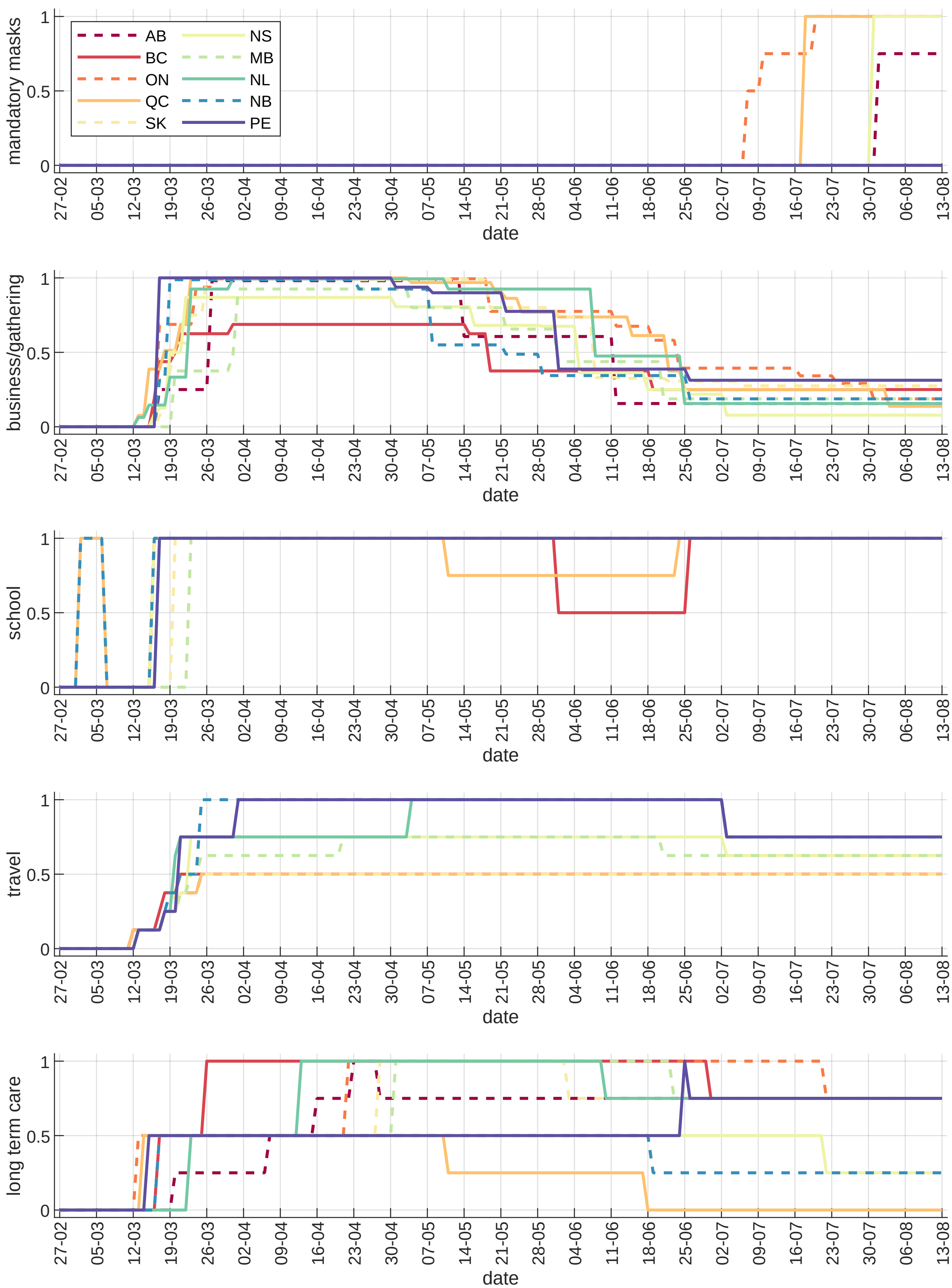
Many NPIs were implemented at the same time, both relative to each other and/or across regions, especially during the March closing-down period. This causes many of the policy indicators to be highly correlated with each other (see Appendix Table A4). To avoid multi-collinearity issues, we therefore group, via simple averaging, the 17 policy indicators into 5 policy aggregates: (i) *travel*, which includes international and domestic travel restrictions and self-isolation rules; (ii) *school*, which is an indicator of provincial school closure (including Spring and Summer breaks); (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 the policy.[18]

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.[19] 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 $j = 1, ..., 5$ denotes policy type) by taking a weekly moving average of the raw policy data, from date $t-6$ to date t.

[18] 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*.

[19] 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 (see Fig. 1) and the respective PHUs population sizes.

Figure 2 plots the values of the 5 policy aggregates over time for each of the 10 provinces. Travel restrictions, school closures 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 more policy intensity variation, especially in the business and gatherings category, as the different provinces implemented their own re-opening plans and strategies. Mask mandates were introduced in Ontario starting from June in a few smaller PHUs and in early July in some of the most populous PHUs, Toronto, Ottawa and Peel (see Appendix Table C2). In Quebec, indoor masks were mandated province-wide on July 18. Nova Scotia (province-wide) and Alberta's two main cities Calgary and Edmonton implemented mask mandates on July 31 and August 1, respectively.

There are two empirical challenges specific to the Canadian context and data. The first challenge is the presence of small provinces or sub-regions with very few COVID-19 cases or deaths. In Section 4.3, we perform 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).[20] On the positive 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 PHUs and provinces. To address these data limitations and the possible impact of collinearity on the estimation results, we use

[20] Alternative methods of computing the standard errors are explored in Section 4.3.

as proxy for behavioural changes the simple average of three mobility indicators: "retail", "grocery and pharmacy" and "workplaces".[21] To be consistent with the weekly outcome variables and to mitigate day-of-the-week geo-location 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.[22] As a result, our empirical analysis uses weekly totals (for cases, tests and deaths) or weekly moving averages (for policies and the behaviour proxy) for all variables recorded on daily basis.

Tables A3 and A4 display the correlation between the behaviour proxy B_{it} and the five policy aggregates P_{it}^{j}. The behaviour proxy and mask mandate variable are not highly correlated, suggesting that the effect of mask mandates on COVID-19 outcomes is likely not dependent 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} used in estimation equation (1). Specifically, we use as information the lagged value of the weekly case growth rate, $\Delta \log(\Delta C_{it-l})$ and the log of past weekly cases, $\log(\Delta C_{it-l})$. We also use the lagged provincial (in the Ontario analysis) or national (in the 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 all baseline analysis. In the supplementary analysis using the death growth rate as the outcome, we use information on past deaths and a four-week lag (see Section 4.6).

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}. We also include a time trend: our baseline results use a cubic polynomial in days, and we also report results with no time trend and with week fixed effects. In robustness checks, we 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 data and the period March 11 to August 13 for the analysis with provincial data. The end date reflects the 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

[21] 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 included in our location behaviour proxy B_{it}. Furthermore, the "parks" indicator does not have clear implication for COVID-19 outcomes.

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

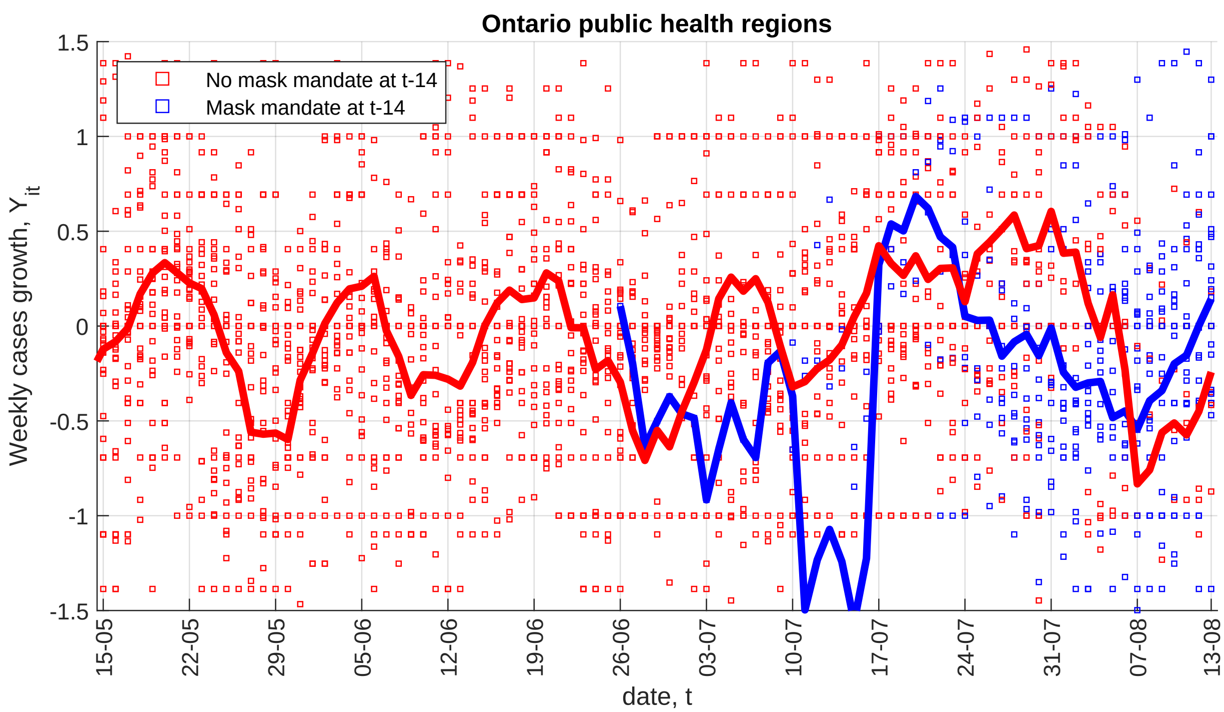
in Ontario. Sensitivity checks with different initial dates (May 1, June 1 and June 15) are reported in Section 4.3, with our main results remaining robust. The initial date for the Canada sample (March 11) was chosen as the first date on which each province reported at least one COVID-19 test (so that cases could be potentially reported). Alternative initial dates are also considered 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 and without mask mandates. 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 Δlog(ΔC) in the PHUs with mask mandate (blue) and 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.[23] We report wild bootstrap p-values clustered at the PHU level to account for the small number of clusters.[24] The odd-numbered columns in Table 1 use lagged cases and lagged case 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.[25]

We present estimates of equation (1) from three specifications that handle time effects differently. Columns (1) and (2) in Table 1 are the most basic specifications, without a time trend. To control for additional possible province-wide factors affecting the spread of COVID-19, e.g. income support policies, adaptation to the pandemic over time, or so-called COVID fatigue, we also estimate (1) including a cubic time trend in days from the beginning of the sample, in columns (3) and (4) of Table 1, and including week fixed effects, in columns (5) and (6).

The estimates in Table 1 imply that, controlling for other policies, information, testing, and geo-location mobility behaviour, mandatory indoor face masks are associated with a decrease of 29.1 to 37.6 log points ($p < 0.05$) in the weekly growth rate of new cases ΔC_{it}, two weeks after their implementation. This result can be interpreted as a 25–31% weekly reduction in new cases, relative to the trend without mask mandate.[26]

Columns (3)-(6) of Table 1 show that our estimates of the mask mandate policy remain robust to the inclusion of cubic time trend or week fixed effects. The magnitude of the mask policy estimates is not very sensitive to whether lagged province-level data are included as additional information.

The results in Table 1 indicate that indoor mask mandates can be a powerful preventive measure in the COVID-19 context. Our estimates of the mask mandate impact in Ontario's PHUs are larger than the 9–10 percentage point reduction in case growth estimated by CKS (2020) for the U.S. A possible explanation is that Ontario's mask mandates are more compre-

[23] Mask mandates and regulations on businesses and gatherings vary at the PHU level. Long-term care policy changed only province-wide. The school and travel policies do not vary in the sample period and hence are omitted from the analysis with Ontario PHU data.

[24] 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 bootstrap standard errors two-way clustered by PHU and date. Our results are robust to alternative ways of computing standard errors.

[25] In all tables, *Variable_14* denotes the 14-day lag of *Variable*.

[26] Using equations (1) and (3), a coefficient estimate $\hat{\pi}$ on Mask_14, as the latter changes from 0 to 1, corresponds to a $\exp(\hat{\pi})-1$ percent change in the ratio of current-week to past-week cases, $\Delta C_{it}/\Delta C_{it-7}$. For example, suppose weekly cases in weeks 1, 2 and 3 are 100, 150 and 225 respectively, showing a 50% weekly case growth. Our estimates suggest that, all else equal, a mask mandate implemented at the beginning of week 1 would reduce week 3 cases to 155–169 (instead of 225 in absence of mandate), with continued reductions in the next several weeks.

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
PHU fixed effects	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 (1.4% of all observations) for Behaviour proxy_14 are imputed via linear interpolation.

hensive: 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 be a factor; we discuss this potential mechanism in Section 4.4.

The results in Table 1 also show a statistically significant negative association between information (log of past cases, $\log(\Delta C)\_14$) 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 certain behavioural responses to information, the negative estimate on past cases, $\log(\Delta C)\_14$ in Table 1 suggests that our location-based proxy may not capture other important aspects of behaviour, e.g., frequent hand-washing or physical distancing. In fact, our coefficient estimate on the behaviour 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).[27] In Appendix Table A18, we find strong contemporaneous correlations between the policy measures, log cases, and the Google mobility behavioural proxy from estimating equation (2). This suggests that the information (lagged cases) and the lagged policy variables included in equation (1) may absorb lagged behavioural responses proxied by B_{it-l} or other latent behavioural changes not captured by B_{it-l}.

4.2 Province-level results

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

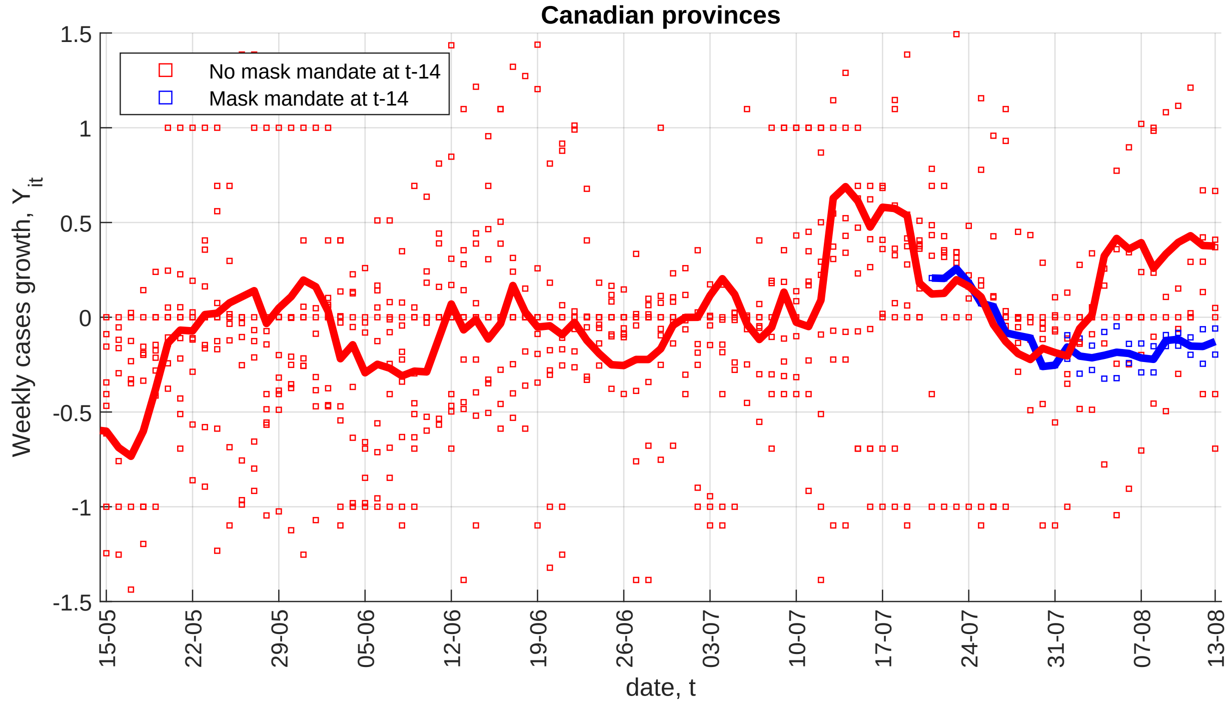
As in the Ontario analysis, we begin with a graphical illustration of mask mandates and COVID-19 case growth across Canadian provinces, from March 11 to August 13, 2020. Figure 4 plots the average log weekly case growth in the provinces with and without mask mandates two weeks prior. While mask mandates 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 two to four weeks after the mandates are imposed.[28]

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 additionally

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

[28] 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).

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.

include lagged cases and case growth at the national level.

As in Table 1, we present in Table 2 estimates from three specifications: no time trend (columns (1)-(2)), with cubic time trend in days (columns (3)-(4)) and with 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 corresponds to a 36 to 46% weekly reduction in new cases across the different specifications, relative to the trend in absence of mandate. 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 province-level results regarding mask mandates are consistent with our results for Ontario PHUs 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 corresponds to a 48 to 57% weekly decrease in new cases in our sample period, relative to the trend in absence of mandate. The business/gathering estimates are, however, noisier than our estimates for the mask mandate policy and do not retain statistical significance in the

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 5,000 repetitions are reported in the square brackets. ***, ** and * denote 10%, 5% and 1% significance level respectively. NC denotes national total cases.

specifications with week fixed effects ($p = 0.15$ and 0.14). Tables A8 and A15 in the Appendix 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 findings suggest that relaxed restrictions and the associated increase in business and workplace activity or gatherings (including restaurants, bars and retail) can be an important offsetting factor for the estimated impact of mask mandates on COVID-19 case growth, both in our sample and at later dates.

We also find that school closures (the School_14 variable in Table 2) are negatively 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 in March, so we lack statistical power to separately identify their effect from that of other NPIs (especially travel-related restrictions). Hence, we interpret this result with caution. Finally, as in Table 1, past cases, $\log(\Delta C)$_14, are 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 non-monotonic aggregate time trends in case growth in a parsimonious way, we choose it as our baseline specification for robustness checks and counterfactual exercises.[29]

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.[30] Thus, we may lack sufficient regional variation to distinguish and identify the separate effect of each policy.[31] Collinearity could also affect the standard errors and the signs of the estimated coefficients.

To check robustness with respect to potential collinearity in the policy variables, Tables A7 and A10 report estimates from our baseline specifications with cubic time trend, omitting one policy at a time, for Ontario and Canada respectively. First, 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.

[29] Sensitivity analysis with the other specifications is available upon request.

[30] Table A4 shows a correlation of 0.61 between the Travel and School policy aggregates.

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

Treatment of zero weekly cases

Another possible concern is that the dependent variable $Y_{it} = \Delta \log(\Delta C_{it})$ is not well defined when the weekly case totals ΔC_{it} or ΔC_{it-7} is zero. As in CKS (2020), we replace log(0) with -1 in our baseline analysis.[32] 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 the baseline results from columns (3) and (4) in Table 1 for Ontario. Our main results on mask mandates in 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 address the issue of PHUs with very few cases is to estimate a weighted least squares regression in which the PHUs are weighted by population. Columns (7) and (8) in Table A5 show that the resulting mask mandate 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 alternative specifications as above. In columns (9) and (10) of Table A8, we also restrict the sample to only the largest 4 provinces (British Columbia, Ontario, Quebec and Alberta), for which only 0.3% of observations (2 out of 624) are zeroes. Again, the estimated mask mandate effect changes very little.

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 with 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 initial dates.

Alternative lags

We explore alternative time lags, of either shorter or longer 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 mandate estimates remain fairly consistent for different plausible lag values.

Omitted variables

Our behaviour proxy variable (Google geo-location trends) likely misses some aspects of behaviour that could be relevant for COVID-19 transmission. One factor that may impact behaviour is weather. For example, good weather may cause more people to spend time

[32] 535 out of 3,094 observations (17%) in Table 1 and 230 out of 1,560 observations (15%) in Table 2 are affected, mostly in the small provinces or PHUs. When both ΔC_{it} and ΔC_{it-7} equal zero, the weekly case growth rate is $Y_{it} = 0$.

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[33]) as additional regressors. Our NPI estimates, in particular for mask mandates, are little changed from the baseline results in columns (1) and (2).

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 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 Mask usage

The effectiveness of any NPI or public policy crucially depends on whether and how it affects behaviour. In this section, we use self-reported survey 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 (Jones et al. 2020), which includes multiple waves of public opinion surveys fielded regularly since early April 2020 in many countries.[34] Here, we focus on inter-provincial comparison within Canada. Our variable of interest is based on the 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 in the Appendix plots the average self-reported mask usage (the response "Always") in the provinces with and without mask mandates.[35] The figure clearly shows that self-reported mask usage is higher, by up to 50 percentage points, in the provinces

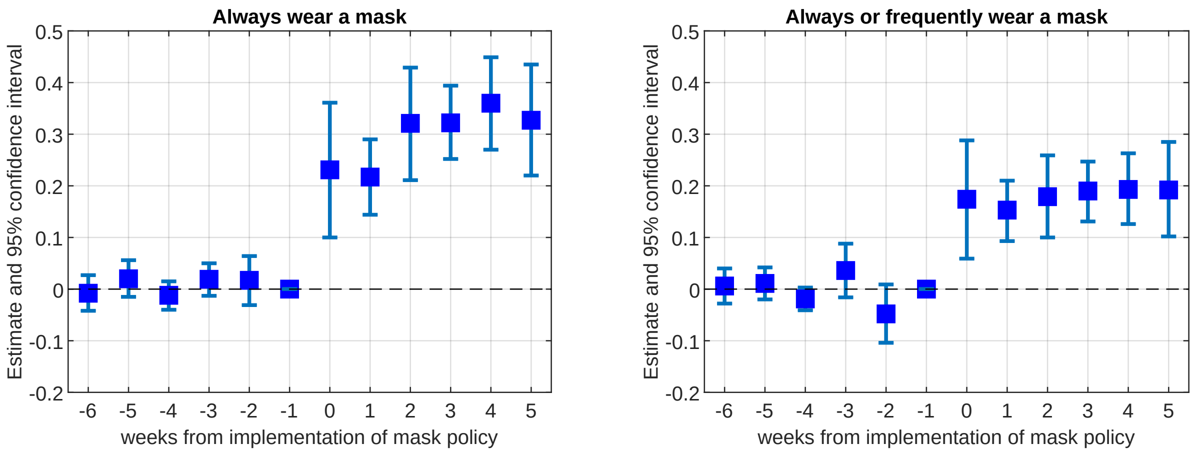
[33] Vancouver, BC; Calgary, AB; Saskatoon, SK; Winnipeg, MB; Toronto, ON; Montreal, QC; Moncton, NB; Halifax, NS; Charlottetown, PE; and St. John's, NL.

[34] The YouGov data is available at: https://yougov.co.uk/covid-19.

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

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 behavioural outcome.[36]

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 a variable denoting being in the treatment group (imposed mask mandate) with 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 5,000 repetitions are used to construct the confidence intervals. Sample weights are used.

Figure 5 shows a graphical event study analysis of mask mandates and the change 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 that we study, for which any impact is expected to occur with a lag and for which we use weekly totals or moving averages. We replace the mask policy variable in equation (2) by the interaction of a variable denoting being in the treatment group (i.e. under a mask mandate) with 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 in 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

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

several observations. First, neither panel shows a pre-trend – the estimates are close to zero before the mask mandates are implemented. 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]
$\Delta\log(\Delta C)$	-0.017	-0.006	-0.008	-0.006	-0.004	-0.008
	[0.663]	[0.611]	[0.524]	[0.595]	[0.656]	[0.464]
$\log(\Delta C)$	-0.025	0.015 **	0.004	0.006	0.006	0.007
	[0.127]	[0.025]	[0.662]	[0.544]	[0.504]	[0.502]
$\Delta\log(\Delta NC)$		-0.106 *		-0.023		0.191
		[0.054]		[0.324]		[0.108]
$\log(\Delta NC)$		-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 that 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 additionally include lagged cases and case growth at the national level. 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%.[37,38]

These "first-stage" results show that mask mandates exhibit broad 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 larger.[39]

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 investigate this question using the 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) ($p < 0.10$).[40]

4.5 Counterfactuals

We evaluate several counterfactuals in which the actual mask policy in a province or Canada-wide is replaced by an alternative policy. Letting t_0 be the implementation date of a counterfactual policy, we set the counterfactual weekly case count, ΔC^c_{it}, equal to ΔC_{it} for all $t < t_0$. For each date $t \geq t_0$, using the definition of Y_{it} in (3), we compute ΔC^c_{it} and the

[37] 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".

[38] 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).

[39] 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.

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

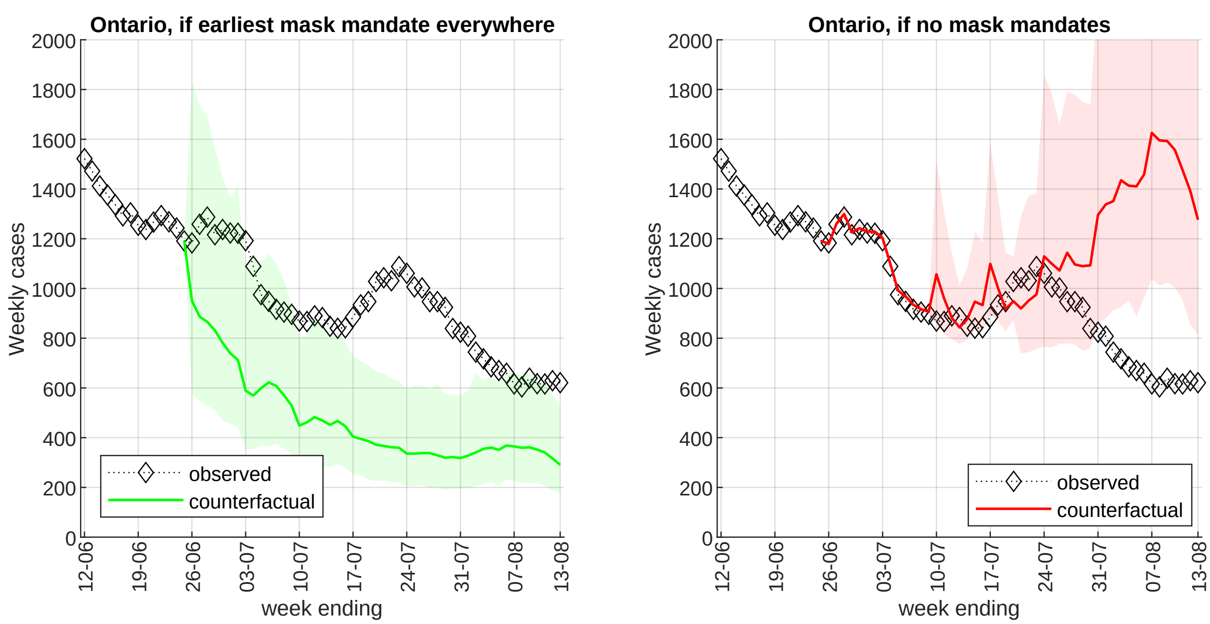
counterfactual weekly case growth rate, Y^c_{it}, as follows:

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

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

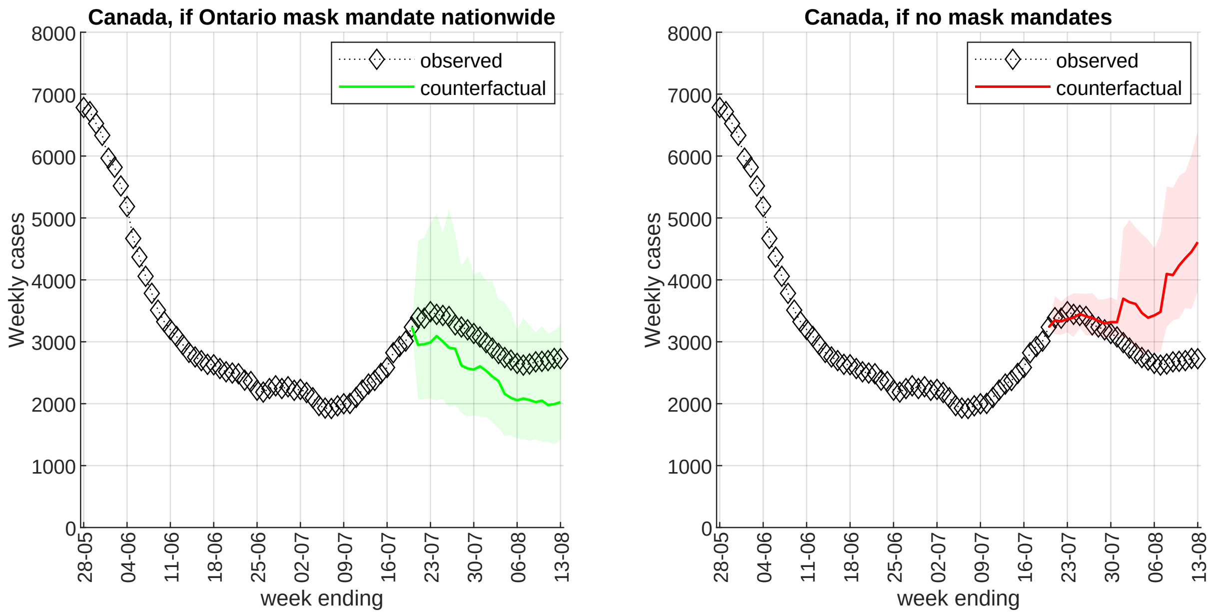
where $\hat{Y}_{it}$ is the regression-fitted value of weekly case growth; β_{Mask_14} is the coefficient estimate (-0.376 or -0.613) on the mask mandate variable Mask_14 in baseline specification (column 4) in Table 1 or 2, depending on the counterfactual; Mask^c_14 is the counterfactual mask policy (e.g., different implementation date, wider geographic coverage or absence of mask mandate); and $\beta_{\log(\Delta C)\_14}$ is the coefficient estimate (-0.209 or -0.227) 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 feedback effect may be due to people being more careful when they perceive the risk of infection to be higher.

Figure 6: Counterfactuals - Ontario public health regions



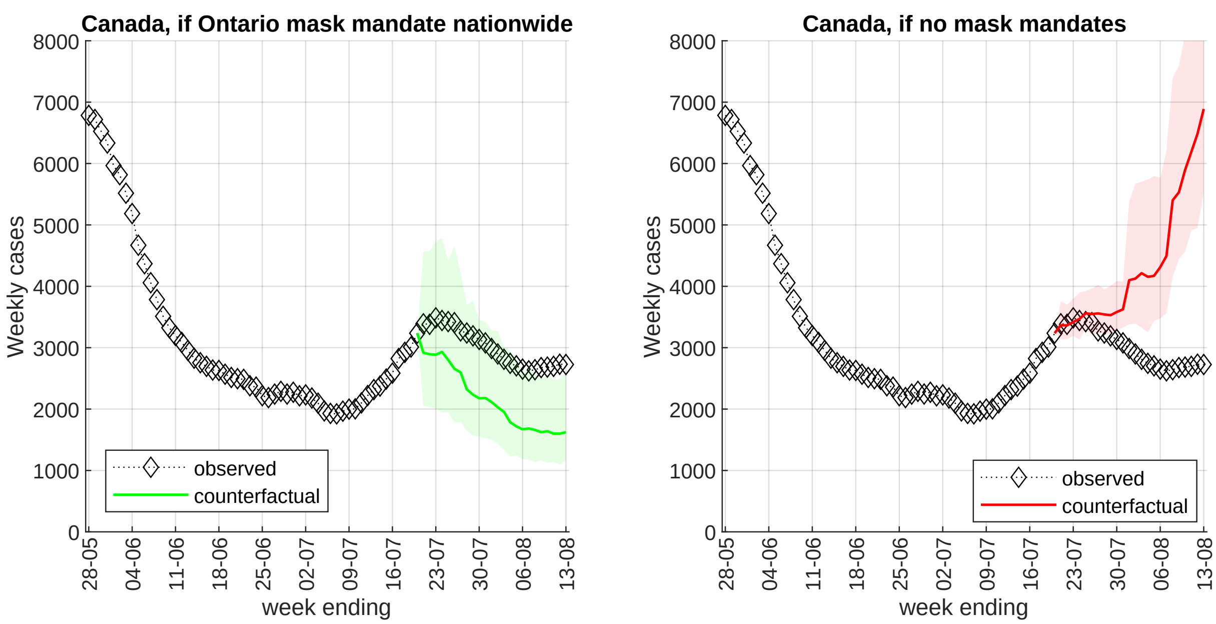
Notes: The left panel assumes that mask mandates were adopted in all PHUs on June 12 (date of the first mask mandate in ON). The right panel assumes that mask mandates were not adopted in any PHU. We use the mask estimate (-0.376) from column (4) of Table 1. The counterfactual mean value (the green or red solid lines) and confidence bands (shaded area) are displayed.

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. The counterfactual mean value (the green or red solid lines) and confidence bands (shaded area) are displayed.

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. The counterfactual mean value (the green or red solid lines) and confidence bands (shaded area) are displayed.

Figures 6, 7 and 8 show results from two counterfactual policy evaluations. The first counterfactual, depicted in the left panels 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 Canadian provinces adopt a mask mandate on July 7.[41] The counterfactual line is set equal to the observed weekly case value and diverges from it after the 14-day lag from implementation (i.e., after June 26 on Figure 6 and July 21 on Figures 7 and 8).

Using our mask policy estimate from Table 1, Figure 6 shows that an early face mask mandate implemented in all Ontario PHUs could have led 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 initial effect of the counterfactual mask policy.

In the right side panels 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 policy coefficient estimate from Table 2 (see Figure 8).

Finally, in Figure B11 in the Appendix, we 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 $t-14$ case counts) remain fixed at their values observed in the data. This is a strong assumption, but it may be plausible over the relatively short period that we analyze. In addition, the counterfactuals assume that regions without a mask mandate would react in the same way, on average, as the regions that have imposed a mandate. Therefore, these results should be interpreted with caution and only offer a rough projection of the estimated impact of mask mandates on COVID-19 cases.

[41] 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 periods

We investigate whether the NPIs 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 preferred 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 $\Delta\log(\Delta C)$ 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 the 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 (May - August), our results in Table A15 are in line with the 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 restrictions and school closures are not statistically significant in the re-opening period. This is unsurprising: any relaxation of travel policies was minor and endogenous (only re-opening to safe areas within Canada), and the schools that re-opened (in parts of Quebec and part-time only in British Columbia) did so on voluntary attendance basis with small class sizes.

Deaths

We also examine the weekly death growth as an outcome variable. We only have disaggregated deaths data at the province level. We estimate equation (1) using $Y_{it} = \Delta\log(\Delta D_{it})$ as the dependent variable, for each province i and date t in the sample period, where ΔD_{it} denotes weekly deaths from date $t-6$ to date t. 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.[42]

[42] In Table 4, *Variable_28* denotes the *Variable* lagged by 28 days.

Table 4: Canada – deaths growth rate and policies

	Outcome: weekly deaths growth, $Y_{it} = \Delta\log(\Delta D_{it})$					
	(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]
Δlog(ΔD)_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(ΔD)_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]
Δlog(ΔND)_28		-0.110		-0.121		-0.019
		[0.471]		[0.476]		[0.806]
log(ΔND)_28		-0.015		0.018		-0.053
		[0.743]		[0.858]		[0.557]
Δlog(ΔT)	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 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. ND denotes national total deaths.

Table 4 reports the estimates from the same specifications as those for case growth in Table 2. In all specifications, a mask mandate is associated with a large reduction in the observed weekly deaths growth rate four weeks later (more than 90 log points reduction in growth, or equivalently more than 60% weekly reduction in deaths relative to the trend in the absence of mask mandate). These estimates are larger than our results for case growth in Tables 2, but not inconsistent with them considering the size of the standard errors. See also Figure B12, which plots the average weekly death growth in the provinces without a mask mandate four weeks prior and in 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.[43] Furthermore, there are only 9 days with observations at least 28 days after the first significant adoption of mask mandates in Ontario, on July 7 (see footnote 41). Due to these data limitations, the relationship between mask mandates and COVID-19 deaths in Table 4 is suggestive at best and caution should be used in reporting or extrapolating from these results.

That said, our findings about mask mandates and COVID-19 case growth in Tables 1 and 2 may have implications about future growth in deaths, particularly if the affected demographics become less skewed toward the young in later periods.

5 Conclusion

The wearing of face masks by the general public remains a contentious policy issue during the COVID-19 pandemic, with large variation in official advice across jurisdictions and over time. "Conspiracy theories" and misinformation surrounding mask wearing abound in social media, sometimes fuelled by the perception that mask mandates constitute restrictions on individual freedoms.

We estimate the impact of face 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 significantly negative association between mask mandates and subsequent COVID-19 case growth: a 25 to 46% average weekly reduction in new cases in the first few 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 shows that the mandates significantly increase the proportion of people reporting always wearing mask in public by around 30 percentage

[43] 205 out of the 1,470 observations (14%) had log(0) replaced by -1.

points. While our sample period and data do not allow us to definitively say whether the mask mandate effect persists beyond several weeks after implementation, the presence of a mandate may serve as an important behavioural anchor, especially in (temporary) periods of plateauing or declining case growth. We conclude that mandating mask wearing in indoor public spaces can be a powerful policy tool to keep COVID-19 transmission at a manageable level, especially given the mandates' relatively low cost to the economy.

Mask mandates were introduced in Canada at a time when other policy measures were relaxed, as part of the economy's re-opening. We find that reduced restrictions on businesses or gatherings are positively associated with subsequent COVID-19 case growth – a factor that can offset and obscure the public health benefits of mask mandates. Past case totals are also found to matter for subsequent COVID-19 outcomes, suggesting that riskier behaviour may follow prior information perceived as favourable. This effect may limit how low the number of new cases can be pushed by mask mandates or other restrictions – short of a lockdown. Importantly, the estimated effect of mask mandates is relative to their absence and not absolute; depending on the situation, a mask mandate may not be sufficient to prevent an increase in new infections on its own and should be considered in conjunction with other policy measures.

We have deliberately refrained from studying 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 jointly considering the epidemiological impact and the economic benefits and costs of the various public policies and restrictions would enrich the ongoing debate and provide further policy 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, $Y_{it} = \Delta\log(\Delta C_{it})$							
	(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]
Δlog(ΔC)_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(ΔC)_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]
Δlog(ΔPC)_14		0.184		0.132		0.094		0.066
		[0.566]		[0.647]		[0.722]		[0.696]
log(ΔPC)_14		0.528		0.302		0.437		0.300
		[0.124]		[0.302]		[0.101]		[0.257]
Δlog(ΔT)	-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 (days)	X	X	X	X	X	X	X	X
weighted							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 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, $Y_{it} = \Delta\log(\Delta C_{it})$	(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	
Δlog(ΔC)_14	X		X	
log(ΔC)_14	X		X	
Δlog(ΔPC)_14			X	
log(ΔPC)_14			X	
Δlog(ΔT)	X		X	
PHU fixed effects	X		X	
cubic time trend (days)	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, $Y_{it} = \Delta\log(\Delta C_{it})$							
	(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
PHU 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 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, $Y_{it} = \Delta \log(\Delta C_{it})$									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Baseline		Alternative 1		Alternative 2		Alternative 3		Alternative 4	
	Replace log(0) by -1		Replace log(0) by 0		Add 1 before taking log		Weighted by population		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 time trend	X	X	X	X	X	X	X	X	X	X
weighted							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 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, $Y_{it} = \Delta \log(\Delta C_{it})$	(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	
Δlog(ΔC)_14	X		X	
log(ΔC)_14	X		X	
Δlog(ΔNC)_14			X	
log(ΔNC)_14			X	
Δlog(ΔT)	X		X	
province fixed effects	X		X	
cubic time trend (days)	X		X	

Notes: The time period is March 11 to 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, $Y_{it} = \Delta\log(\Delta C_{it})$									
	(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 fixed effects	X	X	X	X	X	X	X	X	X	X
cubic time trend (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, $Y_{it} = \Delta\log(\Delta C_{it})$					
	(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 fixed effects	X	X	X	X	X	X
cubic time trend (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]
Δlog(ΔC)	-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(ΔC)	-0.037 *	0.028 ***	0.015 ***	0.015 **	0.016 ***	0.016 **
	[0.079]	[0.004]	[0.000]	[0.031]	[0.002]	[0.012]
Δlog(ΔNC)		-0.158 **		-0.044		0.185
		[0.036]		[0.236]		[0.132]
log(ΔNC)		-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 that takes value 1 if the respondent answered "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 fixed effects	X	X	X	X	X	X	X	X
cubic time trend (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 that 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 fixed effects	X	X	X	X	X	X	X	X
cubic time trend (days)	X	X	X	X	X	X	X	X
average w/o 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 that 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, $Y_{it} = \Delta\log(\Delta C_{it})$	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]
Δlog(ΔC)_14	0.075	0.076	-0.156	-0.157
	[0.184]	[0.250]	[0.105]	[0.136]
log(ΔC)_14	-0.399 ***	-0.413 ***	-0.221	-0.221
	[0.000]	[0.000]	[0.148]	[0.161]
Δlog(ΔNC)_14		-0.120		-0.346
		[0.535]		[0.709]
log(ΔNC)_14		0.285		0.494
		[0.312]		[0.657]
Δlog(ΔT)	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, $Y_{it} = \Delta\log(\Delta D_{it})$					
	(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]
Δlog(ΔD)_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(ΔD)_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]
Δlog(ΔND)_28		-0.121		-0.197		-0.262 *
		[0.476]		[0.244]		[0.065]
log(ΔND)_28		0.018		0.203		0.147
		[0.858]		[0.125]		[0.448]
Δlog(ΔT)	-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 fixed effects	X	X	X	X	X	X
cubic time trend (days)	X	X	X	X	X	X
population weighted					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 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, $Y_{it} = \Delta \log(\Delta C_{it})$					
	(1)	(2)	(3)	(4)	(5)	(6)
	no time trend		cubic time trend		week fixed effects	
Mask_14	-0.228 *	-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]
Δlog(ΔC)_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(ΔC)_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]
Δlog(ΔPC)_14		0.391		0.260		0.572 **
		[0.170]		[0.401]		[0.038]
log(ΔPC)_14		-0.045		0.462		0.128
		[0.841]		[0.168]		[0.712]
Δlog(ΔT)	-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
PHU fixed effects	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.

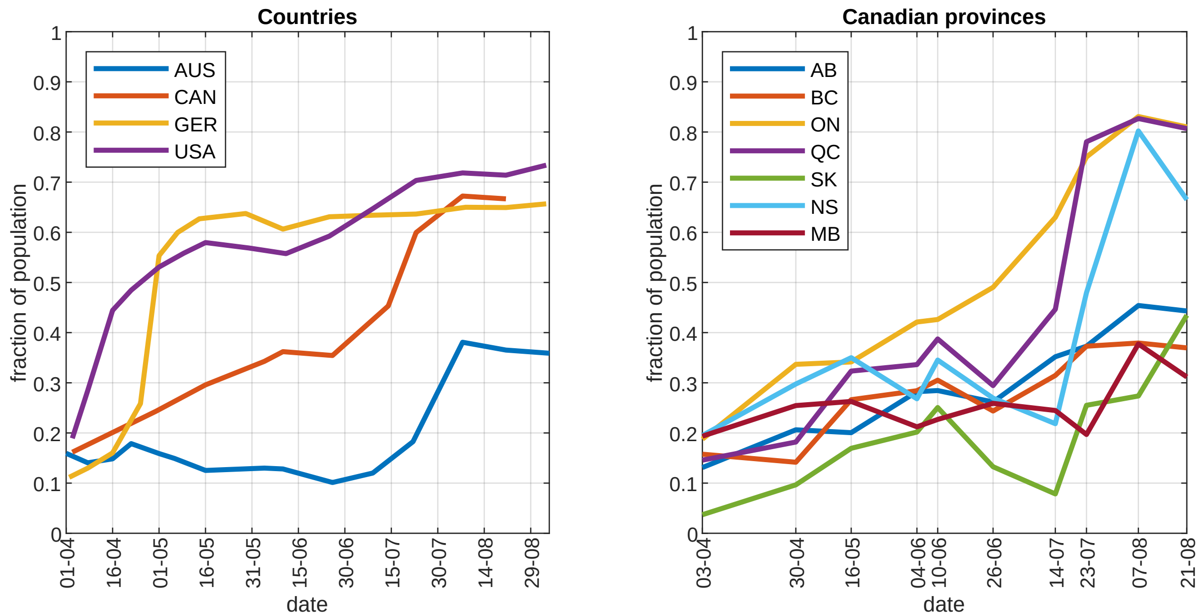
Table A20: Canada – Policy and information only

	Outcome: weekly case growth, $Y_{it} = \Delta \log(\Delta C_{it})$					
	(1)	(2)	(3)	(4)	(5)	(6)
	no time trend		cubic time trend		week fixed effects	
Mask_14	-0.413 ***	-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]
Δlog(ΔC)_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(ΔC)_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]
Δlog(ΔNC)_14		-0.073		-0.221		-0.106
		[0.636]		[0.291]		[0.581]
log(ΔNC)_14		0.121		0.012		0.281 *
		[0.359]		[0.938]		[0.090]
Δlog(ΔT)	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.

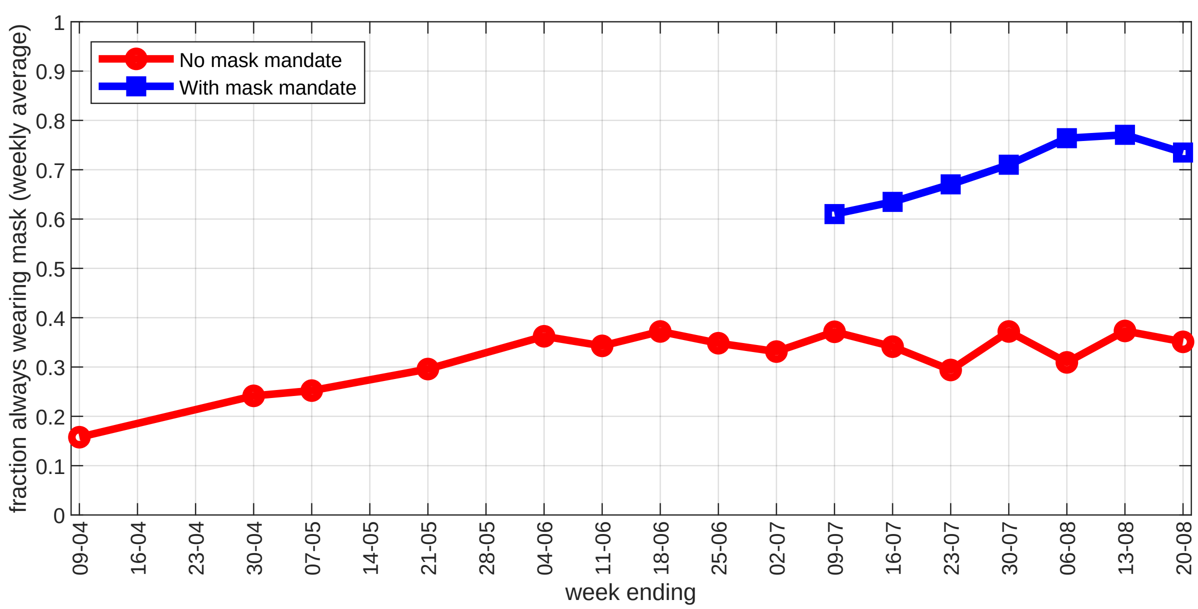
Appendix B. Additional Figures

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



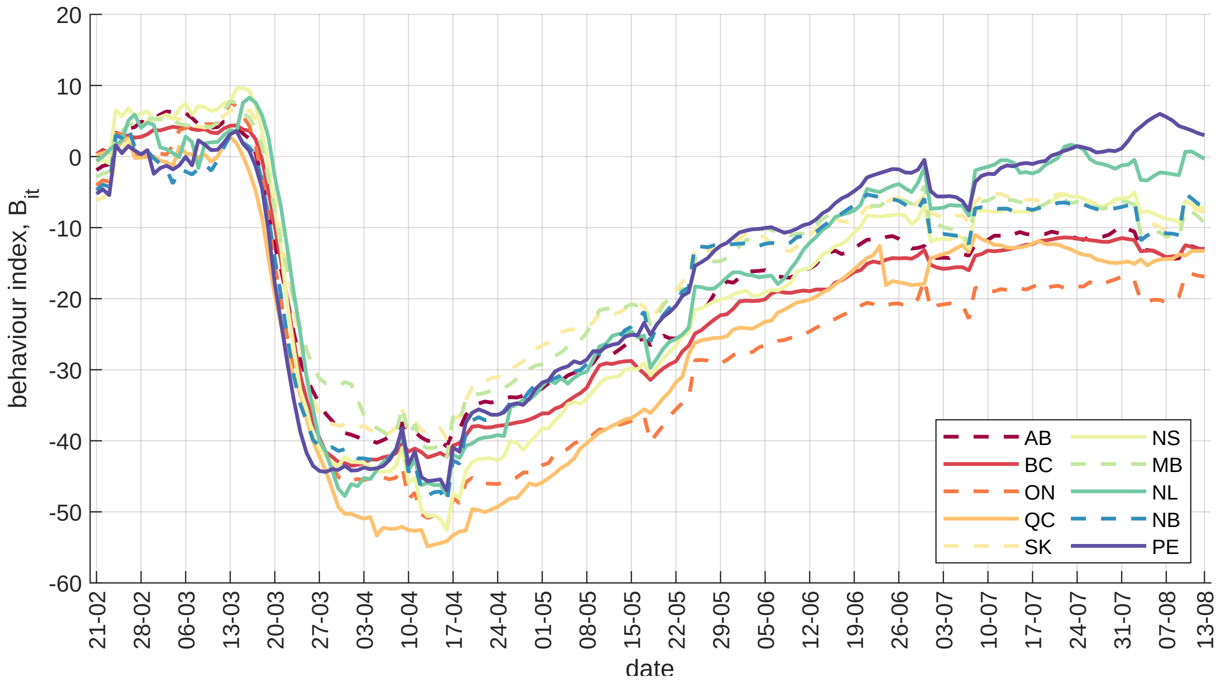
Notes: The data source is YouGov. The figure plots the average self-reported mask usage by week (the fraction of respondents that answered "Always" to the survey question "Thinking about the last 7 days, how often have you worn a face mask outside your home?"). Sample weights are used to compute the national and provincial averages.

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



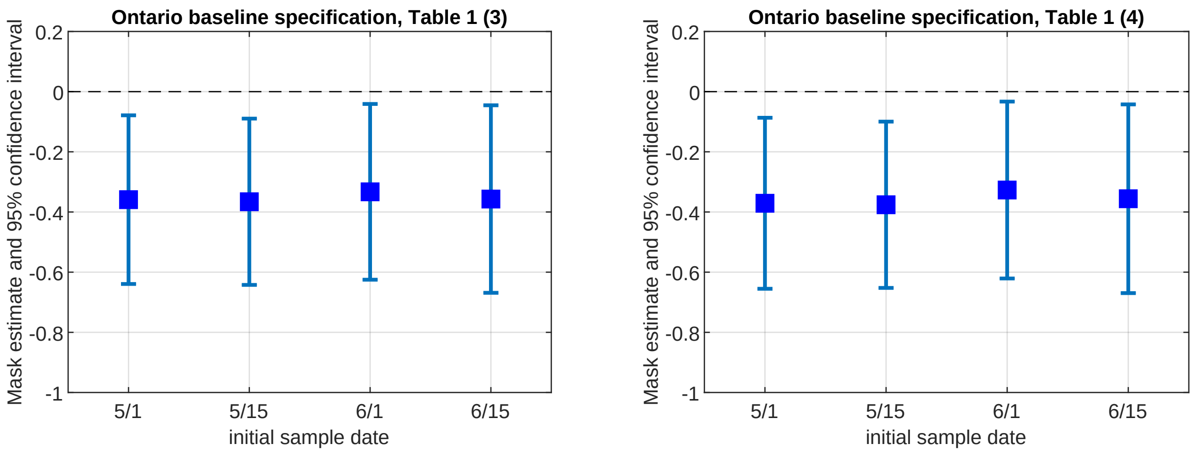
Notes: The data source is YouGov. The figure plots the average self-reported mask usage by week (the fraction of respondents that answered "Always" to the survey question "Thinking about the last 7 days, how often have you worn a face mask outside your home?") in the provinces with and without mask mandates. Sample weights are used to compute the averages.

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



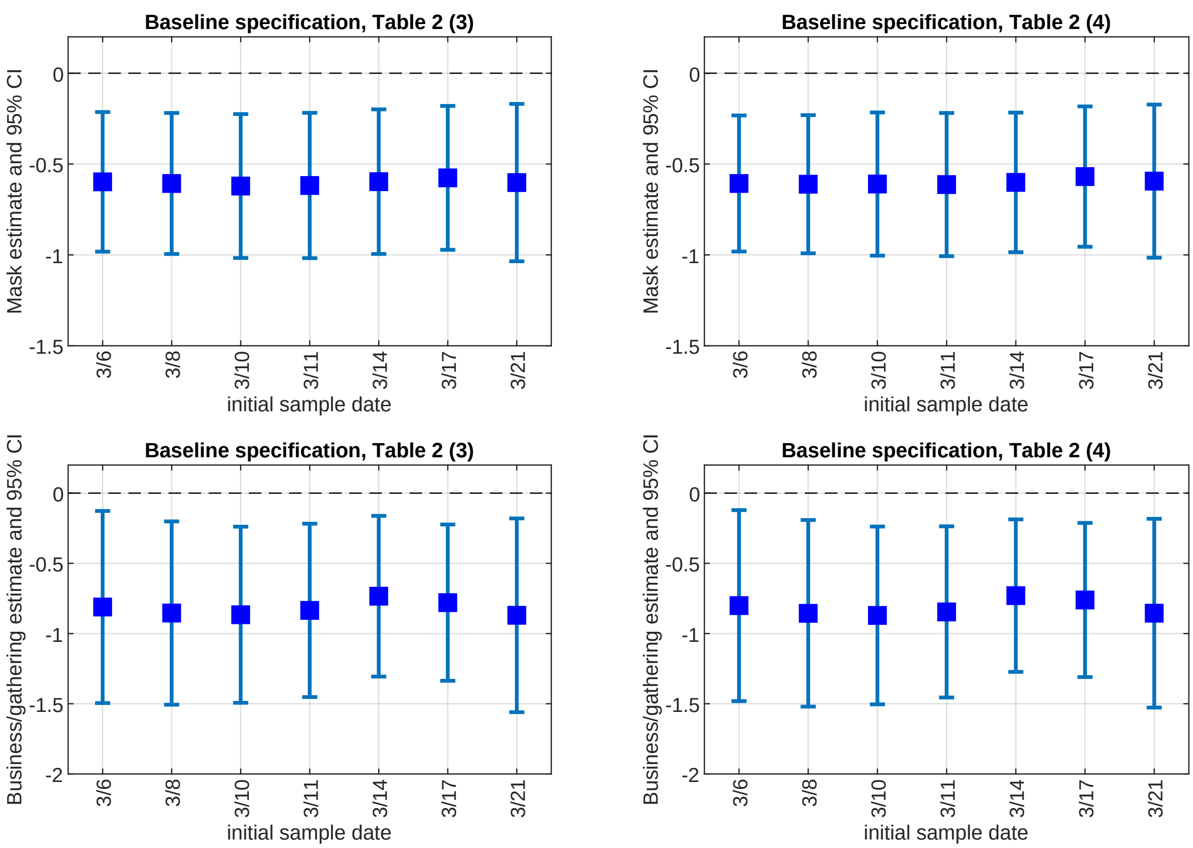
Notes: The Behaviour proxy B_{it} is the average of the "retail", "grocery and pharmacy", and "workplaces" Google mobility indicators. Province-level 7-day moving averages are plotted.

Figure B4: Ontario - different initial dates



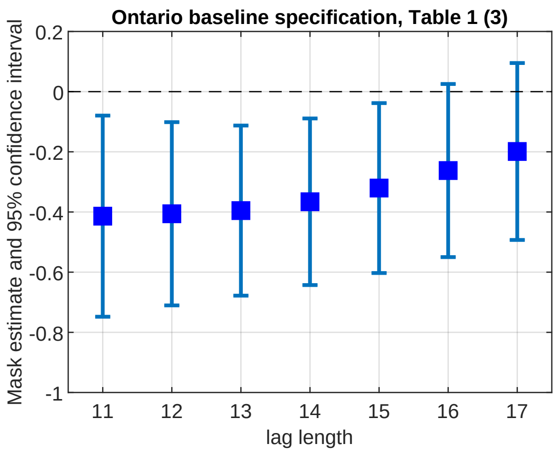
Notes: We plot the coefficient estimates on mask policy, with 95% confidence intervals, from equation (1), for different initial dates of the sample. The initial sample date in the baseline specifications reported in Table 1 is May 15. The left panel corresponds to baseline column (3) in Table 1; the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

Figure B5: Canada - different initial dates



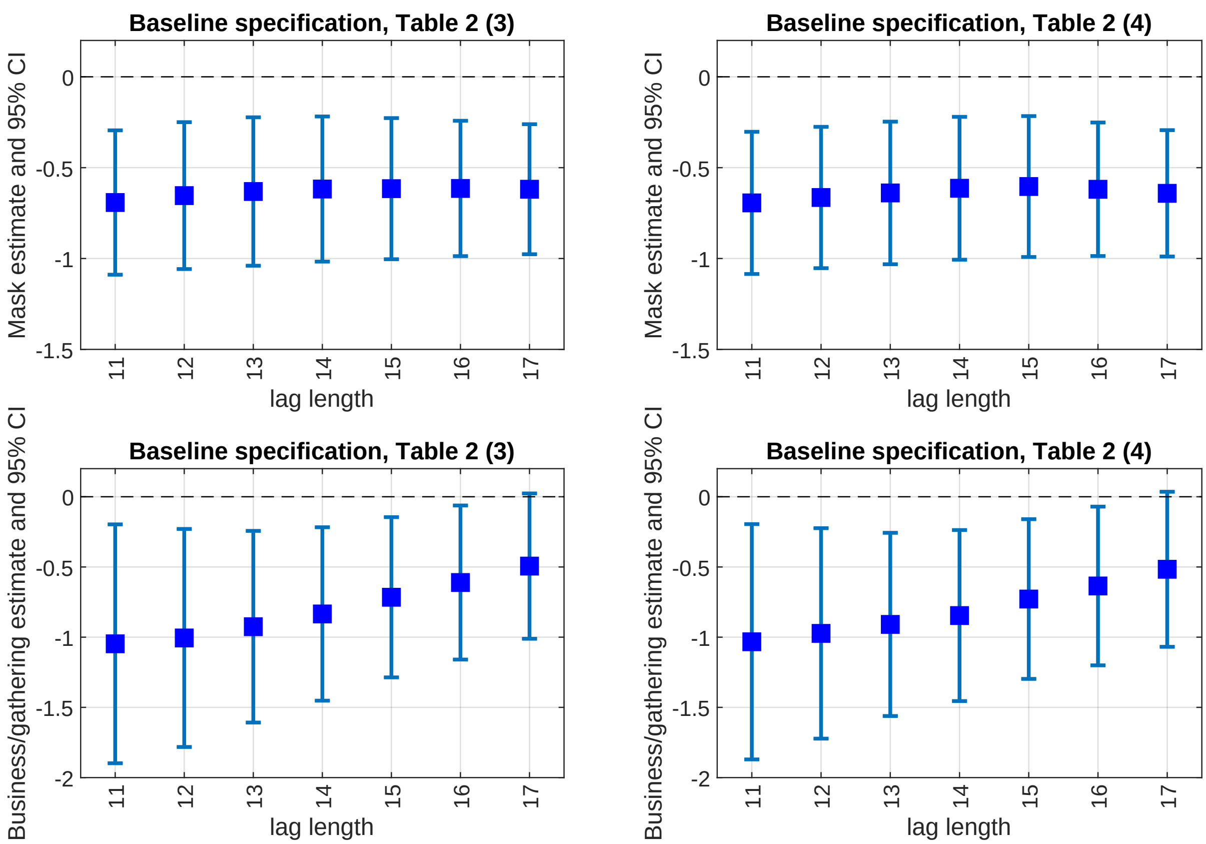
Notes: We plot the coefficient estimates on mask policy, with 95% confidence intervals, in the upper panel and the estimates on business/gathering policy in the lower panel, from equation (1) for different initial dates of the sample. The initial date in our baseline specification (Table 2) is March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

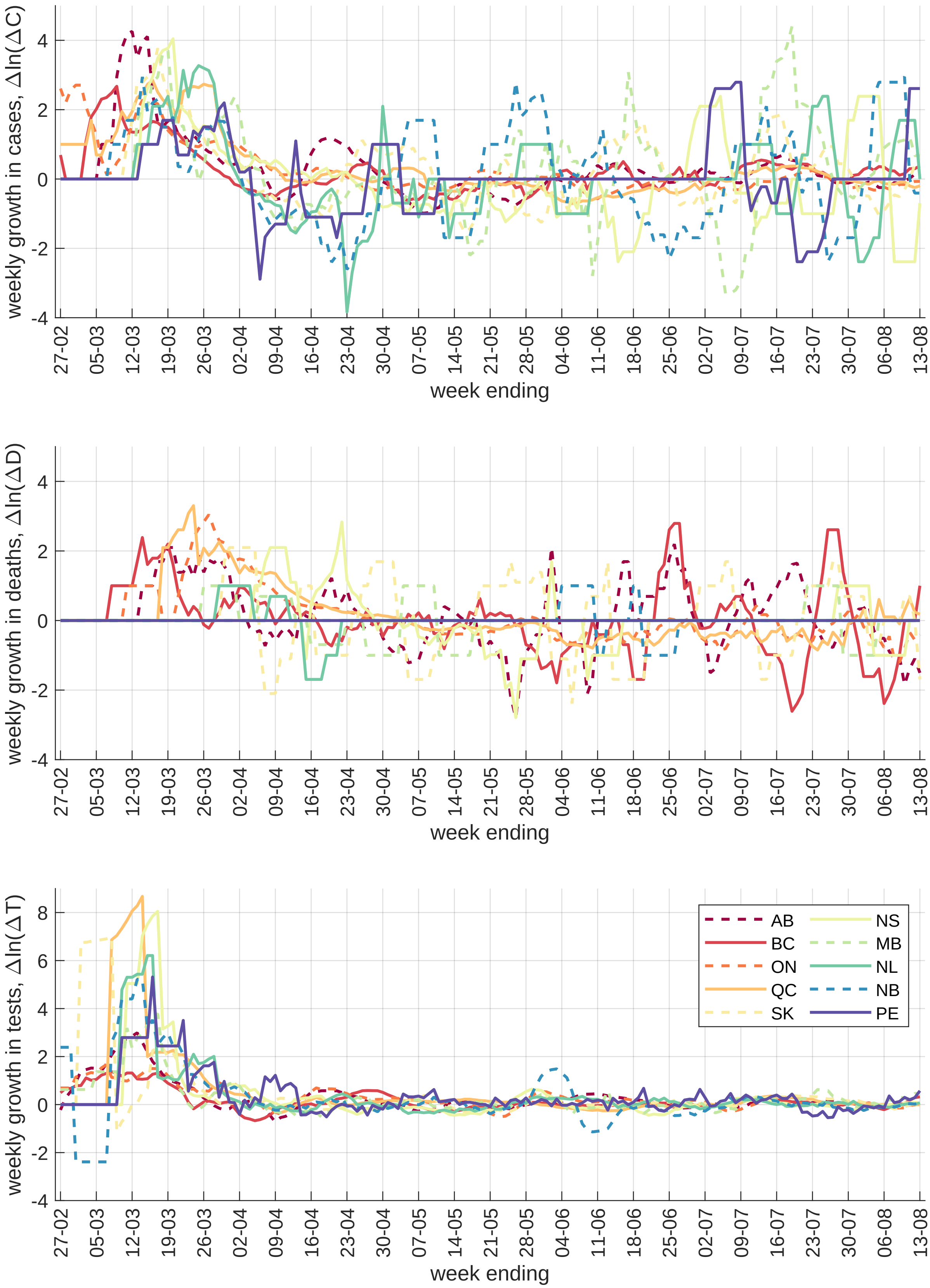


Figure B9: Canada – Weekly cases, deaths and tests (level)

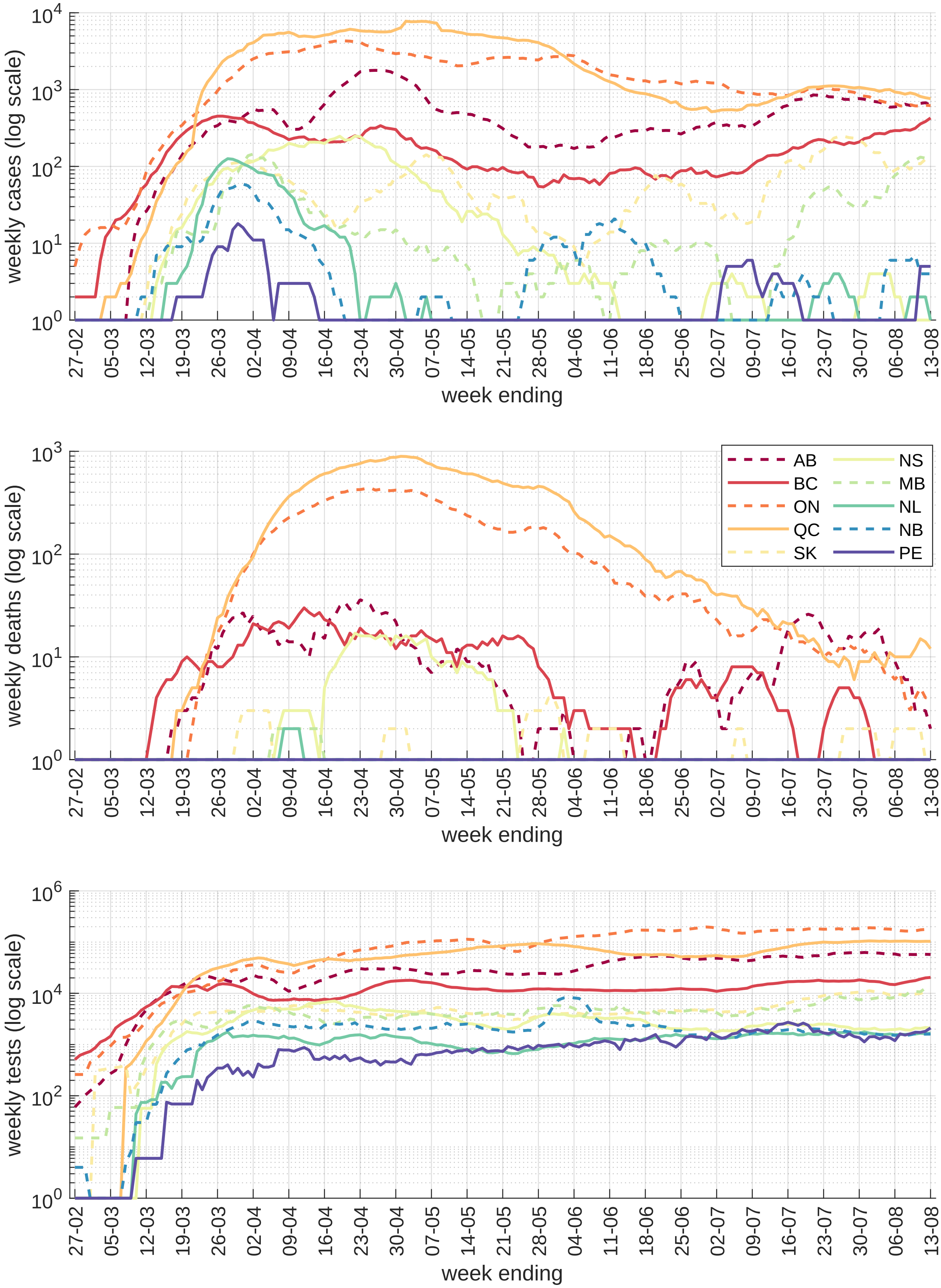


Figure B10: Canada – Daily cases, deaths and tests

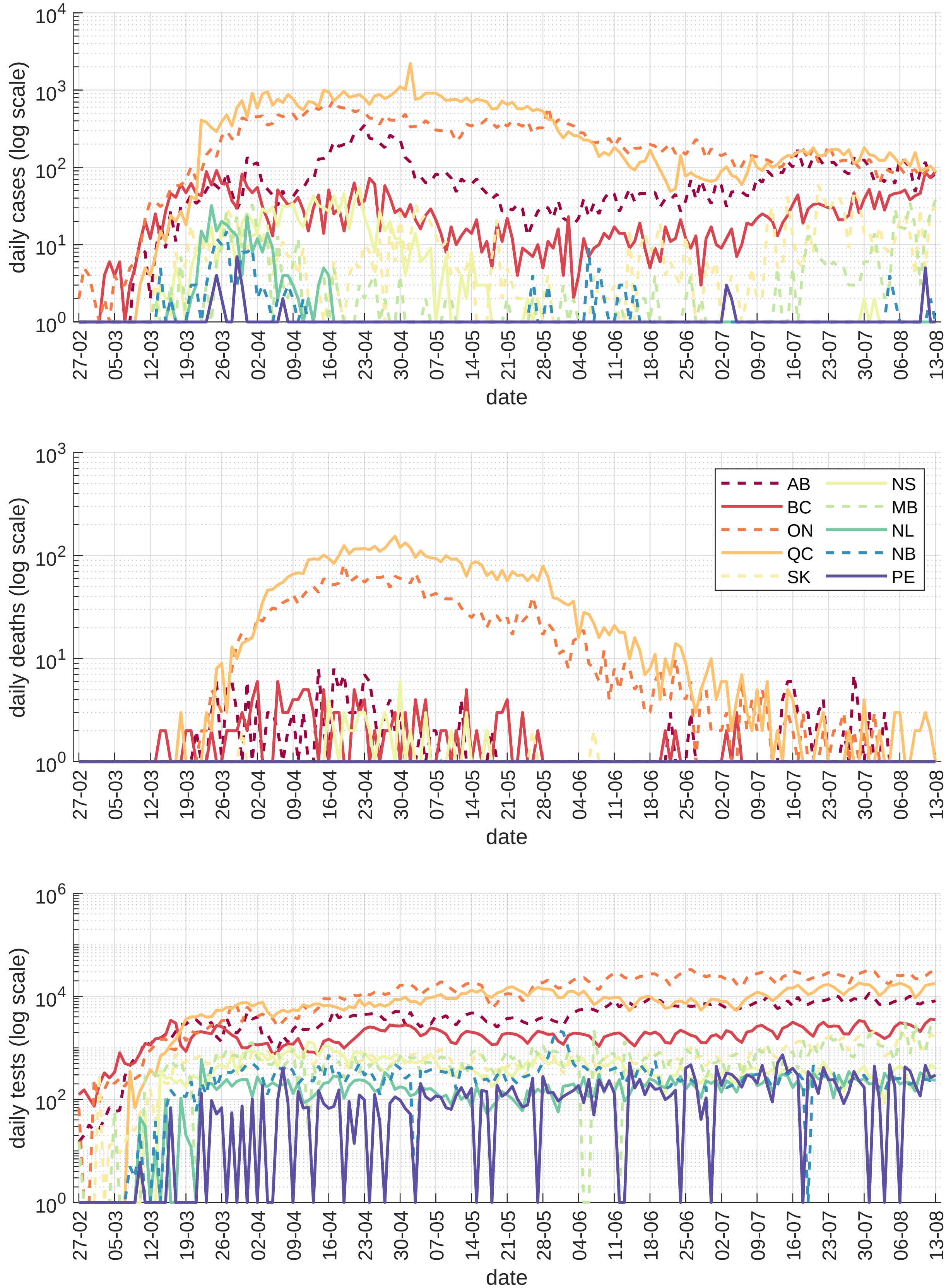
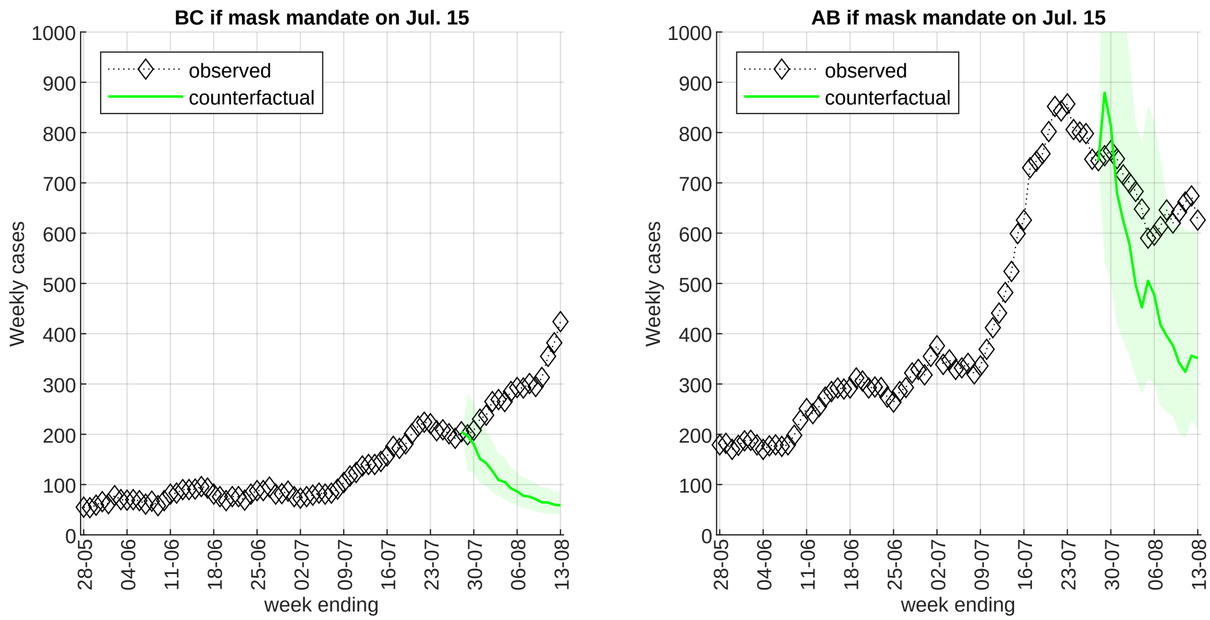
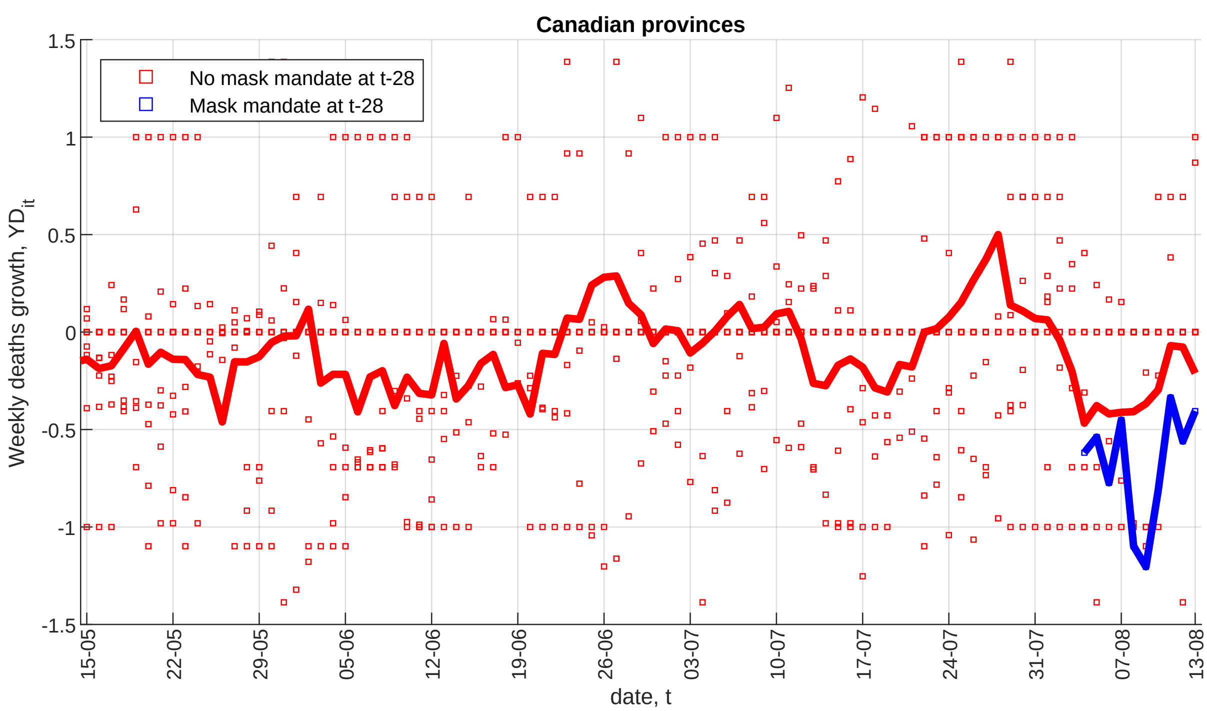


Figure B11: Counterfactuals – Mask mandates in Alberta and British Columbia



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). The counterfactual mean value (the solid line) and confidence bands (shaded area) are displayed.

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 Weather Canada. 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 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 behavioural 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 accordingly set the lag used in our analysis of the death growth rate (Section 4.6) to 28 days.