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SYNTHESIS

Association between Mask Mandates and Population-level COVID-19 Outcomes – What We Know So Far

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Introduction

Public Health Ontario (PHO) is actively monitoring, reviewing and assessing relevant information related to Coronavirus Disease 2019 (COVID-19). "What We Know So Far" documents provide a rapid review of the evidence related to a specific aspect or emerging issue related to COVID-19.

Key Findings

- Available evidence from early stages of the pandemic (March to December 2020) demonstrates that the implementation of mask mandates in community settings was associated with statistically significant reductions in COVID-19 case growth. Estimates of effect size vary widely across the systematic reviews and single studies included in this synthesis and may be confounded by other measures. One ecological study from the United States (US) estimates that mandatory mask policies were associated with a 16% relative reduction in COVID-19 cases over a six-week period.
- Multiple studies from early stages of the pandemic (March to December 2020) have demonstrated an association with mandatory mask policies and reduction in hospitalizations or deaths from COVID-19; however, the effect size may be smaller than for COVID-19 cases.
- Data on the relationship between mask mandates and adherence are limited, although available evidence suggests that mask-wearing adherence increases in regions or time periods where mask mandates are in place and mask-wearing adherence is associated with observed reductions in COVID-19 case growth.
- Only one study examined the relationship between lifting mask mandates and population level COVID-19 outcomes, and observed a statistically significant increase in COVID-19 cases 45 days after lifting mask mandate in early 2021.
- All reviews and studies included in this document report on data collected in a time period prior to the emergence of the Omicron variant of concern (VOC) and COVID-19 vaccination, and therefore may not be directly relevant to the current pandemic context. A majority of the studies summarized in this document examine the real-world impact of mask mandates in the US.

Background

The use of masks in public is one of several COVID-19 pandemic mitigation strategies, within a layered approach that emphasizes vaccination and includes testing, symptom screening, physical distancing, ventilation/filtration, hand hygiene and contact tracing. Mask use may reduce an individual's exposure to respiratory particles from the wearer (source control) and masks as personal protective equipment may also reduce the risk of virus exposure to the wearer.[1] Previous PHO evidence syntheses have summarized the effects of mask-wearing and public mask-wearing mandates on reducing COVID-19 case counts.[1]

This document summarizes the evidence on the association between mask mandates in community settings and population-level severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) outcomes (i.e., incidence, hospitalizations, and deaths) when mask mandates are in place, compared to regions or time periods without mask mandates or with optional, permissive public health masking guidance. Where available, this document will also summarize evidence on the impact of mask mandates on adherence to mask-wearing.

This document will not focus on the efficacy of specific mask types or masking policies in specific settings (i.e., healthcare, schools, and specific workplaces). For more information on existing PHO syntheses on masking, please refer to: Mask-wearing in Children and COVID-19,[2] Use of Face Masks in Non-health Care Workplace Settings to Mitigate the Spread of COVID-19,[3] Interim IPAC Recommendations for Use of Personal Protective Equipment for Care of Individuals with Suspect or Confirmed COVID-19,[4] Community Non-medical and Medical Mask Use for Reducing SARS-CoV-2 Transmission.[5]

Methods

In considering feasibility, scope and timelines, we undertook a rapid review to summarize evidence of impacts of SARS-CoV-2 mask mandates, specifically their association with population-level outcomes. A rapid review is a knowledge synthesis where certain steps of the systematic review process are omitted in order to be timely (e.g., duplicate screening). Prior to publishing, PHO subject-matter experts review all What We Know So Far documents. The information provided in this document is only current as of the date of respective literature searches.

PHO Library Services conducted literature searches on February 15, 2022, in MEDLINE, Embase and National Institutes of Health COVID-19 Portfolio (pre-prints). Search strategies are available upon request. English-language peer-reviewed and non-peer-reviewed records that described the real-world impacts of mask mandates implemented over the COVID-19 pandemic were included for review. Out-of-scope for this rapid review were modelling studies, studies investigating the effectiveness of specific mask types, studies focused on pediatric populations, and studies examining mask mandates in schools, healthcare settings or specific workplaces.

Relevant literature published from June 2021 onward was included in this synthesis. This time period was selected after identifying a systematic review early in the synthesis process that covered the scope of literature on effectiveness of mask mandates up to June 2021.[6] This review is summarized and synthesized in the results below.

Findings

There were 17 articles (16 peer-reviewed, one pre-print) identified that examined the association between mask mandates and three key population SARS-CoV-2 outcomes: COVID-19 cases rates, hospitalizations and mortality.

Despite the date limits in the search, data in these articles reflect a period from March 2020 to December 2020 (with one study examining up to March 2021) prior to the circulation or predominance of Delta and Omicron VOC and broader population-level availability of COVID-19 vaccination. A majority of the articles summarized below reflect the real-world impacts of mask mandates in the United States (US).

Impact of Mask Mandates on COVID-19 Incidence

Two systematic reviews and 12 single studies examined the impact of mask mandates on COVID-19 case rates.[6-19] Overall, the evidence reported a decrease in COVID-19 case growth in regions or time periods where mask mandates or requirements were in place.

Two systematic reviews found that mask-wearing requirements were effective in reducing cases of COVID-19.[6,15] Talic et al.'s systematic review identified in their meta-analysis that mask-wearing was associated with a significant reduction in the incidence of COVID-19 (relative risk 0.5, 95% Confidence Interval [CI] 0.3-0.8, I^2 test for heterogeneity=84%). They also describe a natural experiment study in the US that reported a 29% reduction (risk ratio 0.7, 95% CI: 0.6-0.8) in SARS-CoV-2 transmission measured as time varying reproductive number in states where mask-wearing was mandatory. The review also identified a natural experiment involving 15 US states reporting a 2% statistically significant daily decrease in SARS-CoV-2 transmission at ≥21 days after mask-wearing became mandatory. Lastly, a comparative study in Hong Kong reported a statistically significant lower cumulative incidence of COVID-19 cases associated with mask-wearing when compared to countries where mask-wearing was not mandatory.[6]

Mendez-Brito et al.'s review found that mask-wearing requirements had an intermediate level of effectiveness on reducing COVID-19 case growth. Across the studies in the review, mask-wearing requirements were consistently found to be effective, but were not ranked as the most effective non-pharmaceutical intervention studied (i.e., these were closure of schools, workplaces and businesses, cancellation of public events). Six of the seven studies in Mendez-Brito et al.'s review that analyzed mask-wearing requirements found they were effective at reducing outcomes of interest (i.e., COVID-19 reproduction number, growth rate and incidence). Among the three studies that were of intermediate or high-quality, mask-wearing requirements were among the most effective measures in reducing COVID-19 case growth. One high-quality study from the United States (US) identified mask mandates as the only significant measure for reducing case growth among employees in public-facing businesses.[15]

Twelve single studies examined the impact of mask mandates implemented between January and December 2020 at national, state and local levels and one study that examined the lifting of mask mandates at the state-level in early 2021 (January to March 2021).[7-9,11,14,16-21] These studies demonstrate that the implementation of mask mandates was associated with a decrease in COVID-19 case rates and the lifting of mask mandates was associated with an increase in COVID-19 case rates.

- A matched comparison of 569 US counties (across 46 states and Washington, DC) with and without a mask mandate from March to October 2020 demonstrated that case rates were reduced by 33% (95% CI; 26%-42%) six weeks after implementing a mask mandate with peak impacts at weeks three and four.[8] Data aggregated across six weeks shows the average reduction in case incidence was 16% (95% CI; 8%-23%). The effect was strongest among urban counties and among Republican-leaning counties.

- An analysis of public health measures implemented globally between January and July 2020 demonstrated countries that mandated mask-wearing within two weeks of the first COVID-19 case had lower rates of total cases in later days (between 90-120 days) than those that did not. Among the six measures studied (mask mandate, mass gatherings, travel restriction, lockdown, school closure, restaurant closure), only mask mandates retained strong significance in the association with total case rates over time.[18]

- One study from the US demonstrated the differences in COVID-19 case growth between states with a mask mandate and a mask recommendation policy. Authors reported that between June and September 2020, high COVID-19 case rates were less frequent in states with a strict mask-wearing policy (i.e., required in all public places with consequence of fine/citation) when compared to states with a mask recommendation policy (i.e., required in all public places without consequence of fine/citation for non-compliance).[11] Fourteen of the 15 states with no mask-wearing policy for the general public for the entire four month period (June to September 2020) reported a high COVID-19 rate.

- From April to December 2020, among the 32 states with mask mandates, 63% exhibited a downward trend in confirmed COVID-19 cases within 21 days and 66% within 28 days of implementation of a mask mandate.[9] The study estimated that mask mandates in the 32 states prevented approximately 78,571 and 109,703 cases within 21- and 28-day periods post-mask mandate, respectively. A statistically significant ($p = 0.001$) negative correlation (−0.54) was observed between the rate of cases and days since the adoption of a mask mandate.

- In the US, mask mandates were associated with decreases in daily COVID-19 case growth rates up to 100 days after implementation. Between March 1 and December 31, 2020, state-issued mask mandates were applied in 2,313 (73.6%) of the 3,142 US counties included in the study.[17] The mask mandates were associated with a 0.5% decrease ($p = 0.02$) in daily COVID-19 case growth rates 1–20 days after implementation and subsequent decreases of 1.1%, 1.5%, 1.7% and 1.8% in the time periods of 21–40, 41–60, 61–80, and 81–100 days, respectively, after implementation ($p<0.01$ for all). Daily case growth rates before implementation of mask mandates were not statistically different from the reference period (60 days prior to mandate implementation).

- US states that implemented mask mandates shortly after the release of the Centers for Disease Prevention and Control (CDC) guidance on mask-wearing on April 3, 2020 had the lowest COVID-19 mean cumulative incidence rates compared to states that took longer to implement. After 262 days, states that implemented mask mandates less than a month after the CDC guidance had a cumulative incidence rate of 3,450 cases per 100,000, compared to 4,427 cases per 100,000 (implemented 1-3 months after CDC), 5,290 per 100,000 (implemented 3-6 months after CDC) and 7,362 cases per 100,000 (implemented more than 6 months after CDC or no mask mandate). A COVID-19 case rate ratio analysis demonstrated that states that implemented a mask mandate after more than six months or did not implement a mandate had a case rate that was 2.1 times higher than those who implemented a mandate within one month (95% CI: 1.6-2.9, $P < 0.0001$).[20]

- Similarly, an analysis of mask mandates in the US from September 1 to October 31, 2020 found that early implementation (i.e., by September 1, 2020 as a target date before school reopening) of a state-level mask mandate was associated with a 9% relative reduction in the relative growth of COVID-19 cases after two months.[19] Additionally, the implementation of a state-level public mask mandate prior to lifting a stay-at-home order was associated with a 29% relative reduction in new cases.

- The introduction of mask mandates in the US between February and September 2020 at the state and county levels was associated with a statistically significant and large decrease of COVID-19 cases. Mask mandates were associated with a statistically significant decrease in new cases (-3.55 per 100,000) up to 40 days after the introduction of mask mandates both at the state and county level.[14] The authors also examined the effects of lifting state-level mask mandates in early 2021 (January to March) and found a statistically significant increase in new daily cases (0.55 new daily cases [95% CI: 04-0.7]) 45 days after lifting mask mandates, which corresponds to 12 cases per 100,000.

- The states of Alabama, Louisiana and Mississippi implemented mask mandates in July or August 2020 and saw a decline in their time-varying reproduction numbers by 8.6% (95% Credible Interval: 7.7-9.4%), 18.5% (95% Credible Interval: 1.8-17.2%), and 11.3% (95% Credible Interval: 9.7-13.0%), respectively.[21]

- Two county-level studies in the US demonstrated that counties which implemented mask mandates showed significantly lower average daily COVID-19 transmission rates when compared to other similar counties that did not pass mask mandates.[10,16] One of these studies demonstrated a 60% reduction in COVID-19 cases in counties with a mandate compared to those without.[16]

- Similarly, the Blackfeet Tribal Reservation (Montana, US) introduced a strictly enforced stay-at-home order and mask mandate on September 28, 2020, which was associated with a steep decline (6.4 to 0.2 cases per 1,000) in the number of cases between October 5 and November 7, 2020.[7]

Impact of Mask Mandates on COVID-19 Hospitalizations and Deaths

Two systematic reviews and six single studies examined the impact of mask mandates on COVID-19 hospitalizations and deaths.[6,14-19,22] Overall, studies that examined the impact of mask mandates on hospitalizations found fewer COVID-19 hospitalizations and deaths after mask mandates were implemented. The studies examined population-level SARS-CoV-2 outcomes, rather than case hospitalization and case fatality ratios.

One systematic review identified two studies which demonstrated an intermediate effect of mask-wearing requirements on COVID-19 deaths.[15] Another systematic review identified a natural experiment conducted across 200 countries that demonstrated 45.7% fewer COVID-19 related deaths in countries where mask-wearing was mandatory.[6]

An analysis of public health measures implemented globally from January to July 2020 found that new death rates were negatively associated ($p = <0.05$) with mask mandates up to 12 days after their adoption (-1.8 at 5 days, -1.8 at 9 days, -1.6 at 12 days).[18] This finding was consistent irrespective of whether the mask mandate was strict (i.e., mandate for whole population) or partial (i.e., mandate for sub-population).

Between March to October 2020, an analysis of hospitalization growth rates demonstrated that statewide mask mandates contributed to statistically significant reductions in COVID-19 hospitalization rates when compared to rates during the four weeks before the mask mandate was implemented.[22] After mask mandates had been implemented for three or more weeks, hospitalization growth rates declined by 5.5% in both the 18 to 39 year age group (95% CI = 0.6%-10.4% declines) and 40 to 64 year age group (95% CI = 0.8%-10.2% declines). The overall COVID-19–associated hospitalization growth rates among all adults declined 2.4% (p = 0.04) less than three weeks post-implementation and declined 4.9% (p <0.01) during the period after 3 weeks post-implementation.

Adjodah et al. examined the introduction of state and county level mask mandates from February to September 2020 and the lifting of these mandates in January to March 2021. Authors found that the introduction of mask mandates at the state and county level was associated with a statistically significant and large decrease in new deaths (0.13 deaths per 100,000 people or 13% of the highest recorded number of new deaths) and 2.4% reduction (-2.4% [95% CI: -3.0 to -1.8]) in hospital admissions up to 40 days after the introduction of mask mandates.[14] While Adjodah et al. observed a statistically significant increase in cases after mandates were lifted in January to March 2021, they found no statistically significant effect on hospitalizations and deaths associated with lifting mask mandates in January to March 2021. However, the authors note this could be due to limited data from the recent states which lifted mandates and the effect of vaccines on hospitalizations.

An analysis of mask mandates in the US from September 1 to October 31, 2020 found that the longer-term associations over a two month period were stronger for confirmed cases than for deaths.[19] The 60-day adjusted ratio was 0.9 (95% CI = 0.9-1.0) for deaths compared to 0.7 (95% CI: 0.7-0.8) for cases. Furthermore, the implementation of a state-level public mask mandate prior to lifting a stay-at-home order was associated with a 29% relative reduction in new cases and an 8% relative reduction in new deaths after two months.

State-level mask mandates in the US were associated with decreases in daily COVID-19 death growth rates up to 100 days after implementation.[17] From March 1 to December 31, 2020, state-issued mask mandates were applied in 2,313 (73.6%) of the 3,142 US counties included in the study. To examine the association between state-issued mask mandates with COVID-19 deaths, county-level data on mask mandates were compared with county-level changes in COVID-19 death growth rates relative to the mandate implementation. Mask mandates were associated with a 0.7% decrease in daily COVID-19 death growth rate (p = 0.03) between 1-20 days after implementation with additional decreases of 1%, 1.4%, 1.6%, and 1.9% in the time periods of 21-40, 41-60, 61-80, and 81-100 days, respectively, after implementation (p<0.01 for all). Daily death growth rates before the implementation of mask mandates were not statistically different from the reference period (60 days prior to mandate implementation).

A case-control study of counties in Kansas, US that adopted (or did not adopt) the July 2020 state-wide mask mandate found significantly lower rates of COVID-19 hospitalizations and deaths in counties that adopted the mandate, compared to those that did not.[16] Hospitalization rates in counties that did not adopt the mask mandate were 1.4 times higher those in counties with mask mandates by mid-October 2020 (2.6 hospitalizations per 100,000 compared to 1.8 hospitalizations per 100,000). Deaths were 1.8 times higher in counties that did not adopt the mask mandate by November 1, 2020 (0.6 deaths per 100,000 population compared to 0.3 deaths per 100,000 population).

Mask Mandates and Adherence

Four single studies (three from the US, one that included several international jurisdictions) examined adherence to mask-wearing in regions or time periods with or without mask mandates.[11-14]

The introduction of mask mandates between February and September 2020 at the state- and county-level in the US were associated with a 23.4% increase in mask adherence in four culturally and politically diverse states (Hawaii, Iowa, North Dakota and New Hampshire).[14] Authors observed a delay of approximately four days before an upward trend in mask adherence after the implementation of a mask mandate at the state level.[14] Authors also examined the period of early 2021 (January to March) in which mask mandates were lifted in select states. They observed that in the 25 days prior to lifting a mask mandate, adherence did not significantly decrease. However, after the lifting the mandate, mask adherence was stable up to almost 30 days after lifting, but then a statistically significant decreased up to -3.2% [95% CI: -5.9% to -0.5%] 40 days after the lifting.

Fischer et al. demonstrated a time-delay in the impact of adherence to state-level mask mandates on COVID-19 case growth in US states.[11] Authors abstracted daily percentages of the population who report always wearing a mask in public from the Institute of Health Metrics and Evaluation COVID-19 Projections online database, and calculated the average mask use percentage by month for June to October 2020. States with mask adherence among >75% of the population were associated with lower COVID-19 rates in the subsequent month. The difference in mean COVID-19 rates between states with <75% mask adherence was 140 cases per 100,000.

Fischer et al. also found that in September 2020, there was 47% mask-wearing adherence in the 11 states without a mask policy, all of which experienced high COVID-19 rates in the subsequent month (October 2020). In contrast, there was 68% adherence in the 15 states with a masking policy in September, all of which reported lower COVID-19 rates in October 2020. Of note, there were no states with 75% adherence in September 2020 which authors note may have accounted in part for the spike in COVID-19 rates in October 2020. The authors were not able to measure statistical interactions between mask policy and adherence due to instability arising from small numbers; however, they did estimate odds ratios for mask adherence within subgroups of states with and without mask policy.[11] Odds ratios indicating protection against high COVID-19 case rates remained for all months and policy sub-groups, ranging from 0.8 to 0.9 for states with any policy and from 0.6 to 0.9 for states with no policy.

Pro et al.'s county-level analysis of adherence to mask mandates found that rurality decreased mask-wearing (β=-0.560; p<0.0001) and state-wide mask mandates increased mask-wearing at the county-level (β=0.090; p<0.0001). The percentages of county residents who were non-white (β= 0.002; p<0.0001) and aged 65 years and older (β=0.004; p<0.0001) were positively associated with mask-wearing. Conversely, higher percentages of county residents who voted for the Republican presidential candidate in 2020 were associated with a decrease in mask-wearing (β=-0.084; p=0.013). No association was identified between income inequality and mask-wearing.[12]

Petherick et al. displayed monthly changes in adherence relative to the baseline period (0-30 days after the first required measure) in 14 countries between March and December 2020.[13] Mask use was at least partially required in most countries only two months after the first required measure. After controlling for the strength of the masking policy, the authors found that adherence to mask policies increased progressively with the passage of time. Authors observed an increase of 0.7 points on a five-point scale (95% CI 0.6-0.8, $P < 0.001$) in adherence from baseline to 150-180 days after first required measure, which increased to 1.0 point (95% CI 0.9-1.1, $P < 0.001$) by 240 days after the first required measure.

Implications for Practice

- The available evidence, from observational studies, shows statistically significant associations between mask mandates and reductions in COVID-19 case growth, hospitalizations and deaths. The reduction in COVID-19 cases associated with mask mandates may be larger than reductions in hospitalizations and deaths. The available evidence compared regions or time periods with mask mandates to those without. There is limited evidence on comparing differential effectiveness between permissive masking recommendations and mask mandates.

- There was limited information available on whether adherence differs in jurisdictions with or without mask mandates. The available evidence indicated that mask mandates were associated with increased mask use and that mask adherence may increase over time following the implementation of mask mandates. This suggests that advanced messaging on masking may be necessary to achieve optimal effect at the time when masking is needed based on epidemiologic parameters.

- While mask-wearing behaviours (e.g., knowledge, attitudes, and other contextual factors) were out of scope in this synthesis, some articles noted personal, social, cultural and political factors that impact mask-wearing behaviours. A further exploration of personal and contextual factors that impact mask-wearing behaviours from a social and behavioural science perspective is warranted.

- Other strategies in addition to mandates could be explored to enhance mask adherence. Utilizing evidence-based behavioural science approaches can support enhanced uptake and adherence to public health measures, such as mask mandates. Promising strategies to increase effective masking include persuasion (i.e., framing messages in terms of maintaining well-being rather than avoiding risk), enablement of the behaviour, modelling the behaviour, and clear education.[23]

- Overall, data prior to the emergence of the Omicron VOC and the availability and uptake of COVID-19 vaccination show significant associations between mask mandates and reductions in COVID-19 case rates, hospitalizations, and deaths. Mask mandates also may be associated with increased mask use, which explains the observed findings. The generalizability of these findings to the current context in Ontario, with the predominance of Omicron and significant vaccination uptake, is difficult to ascertain (i.e. to what extent the magnitude of reduction in cases, hospitalizations, or deaths may have changed). It will be important to monitor emerging evidence most relevant to the current context in Ontario.

- The high transmissibility of Omicron, limited two-dose vaccine effectiveness against Omicron infection, and the potential for emergence of further VOC demonstrate the importance of layered public health measures to prevent COVID-19 morbidity and mortality.[24] As the pandemic progresses, mandating mask use in public indoor settings (particularly in settings with 3 C's i.e., closed spaces, crowded places and close contact) will continue to be an important and effective layer of control during periods of exponential case growth, uncertainties associated with the risk from new variants, and to protect vulnerable members of society. Requiring mask use is less restrictive and disruptive to society than many other public health measures applied during the pandemic, such as school or business closures.

- The public health ethics implications of mask mandates were beyond the scope of this review; however, this is a key consideration for ongoing decisions about their use, including the relevance of mask mandates for protecting people most susceptible to severe COVID-19 disease (i.e. older adults and immune compromised individuals), considering ethical dimensions such as equity, reciprocity, individual liberty, proportionality and solidarity.[25]

Conclusion

The implementation of mask mandates has been associated with statistically significant reductions in COVID-19 case growth, hospitalizations and deaths. The information on adherence to mask mandates is limited and requires further study, but available evidence suggests that mask-wearing adherence increases when mask mandates are in place and that this adherence is associated with observed reductions in case growth.

Many of the studies that examined COVID-19 incidence, hospitalizations and deaths during periods in which mask mandates were implemented had layered infection prevention and control measures in place, so it is challenging to measure the independent impact of mask mandates. All studies included in this rapid review were performed prior to the emergence of the Omicron VOC and the availability and uptake of COVID-19 vaccination; thus, it is unclear whether certain findings are applicable to the current context.

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