Emerging Evidence on COVID-19

Rapid Review on the use of Face Masks to Prevent the Spread of COVID-19 in Community Settings: Update 1

Introduction

What is the evidence on face mask use to prevent COVID-19 in community settings?

Of all the public health measures (PHM) that have been used during the COVID-19 pandemic, the use of face masks in the community is a technically simple one that has had little impact on the economy (1). But is it effective? This rapid review summarizes the empirical evidence on the effectiveness of masks to prevent COVID-19 cases in community settings. It is an update to the earlier *Evidence Brief on the use of Face Masks to Prevent COVID-19 in Community Settings, July 2020* (2). This review does not include experimental data on the filterability of different types of non-medical masks, materials or combinations of materials, as this is being covered as a separate review. It also does not include predictive models that estimate the mitigation effects of wearing a face mask alone or in combination with other public health interventions. This review summarizes literature until November 19, 2020.

Key Points

- Forty nine studies were identified on the effectiveness of face masks to prevent COVID-19 in community settings. There was one experimental study, 15 observational studies, 27 ecological studies and six reviews.

- The majority of studies demonstrate that community masking in observational studies and community mask policy implementation in ecological studies is protective against COVID-19, however the magnitude of this effect varied. Variability could be due to when the study was conducted, confounders, and adherence rates.

- Key findings from individual level observational studies (n=15) and a randomized control trial (n=1) include:

  - In seven observational studies, wearing a face mask was associated with a 7.0-79% decrease in COVID-19 infections.

  - A large randomized control trial (DANMASK-19) in Denmark reported insignificant results for mask usage (OR 0.82, 95% CI: 0.54-1.23, P= 0.33), although this trial suffered from low adherence in the mask group likely due to low levels of community masking during the study (3).

  - Cluster and outbreak investigations consistently reported fewer secondary cases when index cases and/or their contacts wore masks.

- - No evidence was found related to differences in effectiveness of masks between adults and children.

- Twenty-six ecological studies demonstrated that face mask policies were associated with a decrease in COVID-19 infections and deaths. There was some variability in the type of face mask policy implemented, most were universal in public spaces, and three were specific to mask policies for employees.

  - In nine studies the effect of universal face mask policies was calculated and the decrease in COVID-19 infections attributed to the policy ranged from 3.2-48%. There was some variability in the type of face mask policy implemented, most were universal in public spaces, and three were specific to mask policies for employees.

  - One study in Canada was identified, which demonstrated that mask policies in Ontario invoked in Jun-Jul resulted in a 25-31% weekly reduction in COVID-19 cases starting two weeks after implementation (4).

  - A study of COVID-19 case reductions the first month after a universal mask policy in New York demonstrated age-related differences. There was a 20.8% reduction in cases for both 65-74 year olds and 75+ year-olds in the first month, whereas 25-44 and 45-64 year-olds were associated with a 4.5% and 8.1% reduction, respectively (5).

  - Three studies of face mask policies that mandated masks for all employees at all workplaces in an area (county or state) found a decrease in COVID-19 infections and deaths (1, 6, 7), although the results were not consistent in magnitude or statistical significance across different models (1).

  - A USA study found that both early and late mask policies were effective in reducing COVID-19 infections (8).

  - The only study that did not show a significant impact with a mask policy was under lock down conditions -1% (95% CI: -13 to 8%) (9).

  - One study found that countries that had a pre-existing norm that all sick people wear masks, had a lower daily growth rate of COVID-19 cases and deaths compared to countries with no pre-existing mask norm (10).

- Implementing a community mask policy instead of only recommending people wear masks has a significant impact on adherence to mask use in public settings. The study from Ontario indicated there was a 30% increase in mask use after mask policies were implemented (4). A similar study in Australia found a mask policy increased mask use by almost 50% (11). In contrast, a study from the USA showed mask recommendations consistently did not have an impact on COVID-19 fatality rates (1).

Overview of the Evidence

Forty-nine articles pertaining to the effectiveness of face masks to prevent COVID-19 in community settings were identified and included in this review. Of these, 23 are preprints or reports and have not completed the peer-review process. The publications reporting on the effectiveness of face masks include a randomized control trial (n=1), longitudinal studies (n=2), cohort studies (n=2), a natural experiment (n=1), a case-control study (n=1), cross-sectional studies (n=5), cluster and outbreak investigations (n=4), ecological studies (n=27), and systematic or rapid reviews (n=6).

Studies where the inference can be made to the individual include randomized control trials that are the gold standard for measuring the impact of an intervention as the randomization process controls for confounding variables and assuming the sample is representative of the population, by design the RCT should isolate the effect of the intervention. The RCT included in this review was done in a community without a universal mask policy and suffered from lack of adherence to mask wearing in the treatment group, missing data, and lack of blinding. Thus this RCT has some risk of bias that decreases confidence that future research will not change the conclusions.

The 15 observational studies assessed individual level data. Cohort studies, natural experiments, longitudinal studies, and case-control studies can have moderate to high risk of bias depending on whether the sampling strategy is able to obtain a representative sample of the target population. Cross-sectional studies provide a single point in time snap shot of an issue, but cannot establish causation, therefore these studies provide low quality evidence. Retrospective cluster and outbreak investigations are at high risk of bias. In many studies outcomes and risk factors were self-reported so may have recall and social desirability bias. In general observational studies cannot establish causation, but can be useful in developing hypotheses or understanding observed factors for transmission.

The 27 ecological studies assessed population level data. These types of study are inexpensive to conduct and can be done quickly as they largely capitalize on publicly available data. They are at high risk of bias due to the use of disparate population level data and are prone to ecological fallacy (what is true at a population level may not apply at an individual level).

The six reviews were evaluated by the AMSTAR tool for systematic reviews to assess whether the conduct of a review minimized bias. The rapid and systematic reviews ranged from low to high quality, depending on the number of reporting and conduct issues in the study. Despite this, there was good agreement in the results across the review literature.

The literature on COVID-19 is rapidly evolving and with time studies with low risk of bias can be conducted to close existing knowledge gaps. An important knowledge gap is a lack of studies where the inference can be made to an individuals' mask compliance (both adherence and proper use) on SARS-CoV-2 infection in community settings. There is also minimal evidence on effectiveness of wearing a face mask or face mask policies for employees, and in school settings.

CONTENTS

EXPERIMENTAL AND OBSERVATIONAL STUDIES ASSESSING PREVENTION

There were 16 studies identified that assessed the effectiveness of face masks to prevent COVID-19 spread in community settings using individual level data (Table 1). This included one experimental study and 15 observational studies.

- The experimental study was a large randomized control trial (DANMASK-19) from Denmark. It showed that when no face mask policy was in place in the community, recommending mask use was not effective. Although those who wore a mask were 18% less likely be become infected with SARS-CoV-2 compared with those who did not wear a mask, these results were not significant (OR 0.82, 95% CI: 0.54-1.23, P= 0.33). Major limitations to this study were variable adherence to mask wearing, missing data, and a lack of blinding (3).

- The 15 observational studies included two longitudinal studies, two cohort studies, one case-control study, five cross-sectional studies, four cluster and outbreak investigations, and one natural experiment. The majority of studies demonstrated that wearing a face mask was protective against COVID-19, however the magnitude varied across studies.

  o A longitudinal study across 24 countries shows that widespread mask-wearing by 100% of individuals in a country to be associated with a 7% (95% CI: 3.94-9.99%) decline in the daily active cases of COVID-19. Over a 30 day period, this accumulated to an 88.5% (95% CI: 68.7-89.2%) decline in active cases (12).

  o A 7.0-7.9% decrease in COVID-19 cases associated with the use of face masks was also found in three cross-sectional, two cohort, one longitudinal, and one case-control study (12-18).

  o A case-control study in Thailand showed that wearing a mask all of the time versus never wearing a mask was associated with decreased risk for SARS-CoV-2 infection (aOR 0.23, 95% CI: 0.09-0.60), whereas inconsistent use was not associated with decreased risk (aOR 0.87, 95% CI: 0.41-1.84) (18).

  o Four cluster and outbreak investigations consistently reported fewer secondary cases when index cases and/or their contacts wore masks (19-22).

Table 1. Experimental and observational studies on the effectiveness of face masks to protect against COVID-19 in community settings (n=16)

STUDY	METHODS	KEY OUTCOMES
Randomized control trials (n=1)		
Bundgaard (2020) (3) Randomized control trial Denmark Apr-May 2020	This RCT assessed whether surgical mask use outside the home reduced the risk for SARS-CoV-2 infection. The study was conducted in a community where masks were uncommon and recommended by public health. 4862 participants were included (3030 were randomly assigned to wear masks and 2994 were assigned not wear a face mask). Study limitations: missing data, variable adherence to mask wearing, patient-reported findings on home tests, no blinding, and no assessment of whether masks could decrease disease transmission from mask wearers to others.	• Infection with SARS-CoV-2 occurred in 42 participants recommended to wear masks (1.8%) and 53 control participants (2.1%). • The between-group difference was 0.3 percentage point (95% CI: 1.2-0.4 percentage point, p=0.38) (OR 0.82, 95% CI: 0.54-1.23, p=0.33). • Adherence to mask wearing was self-reported. Based on the lowest adherence reported during follow-up, 46% of participants wore the mask as recommended, 47% predominantly as recommended, and 7% not as recommended.
Longitudinal studies (n=2)		
Aravindakshan (2020) *preprint* (12) Longitudinal study Global Feb-Jul 2020	A reduced form model econometric analysis was applied to measure associations between reported face mask use and SARS-CoV-2 spread in 24 countries. A longitudinal survey was conducted every 7 days to collect information on NPIs and adherence across 24 countries.	• Widespread mask-wearing by 100% of individuals in a country was associated with a 7% (95% CI: 3.94-9.99%) decline in the daily active cases of COVID-19. Over a 30 day period this accumulated to an 88.5% (95%CI: 68.7-89.2%) decline in active cases.
Rader (2020) *preprint* (23) Longitudinal study USA	Serial surveys were conducted Jun 3- Jul 27 across the USA (N=378,207) to gather data on community mask and social distancing behaviours in different communities. These data were	• There was a significant association between the proportion of people reporting wearing a mask and community transmission control (Rt<1): OR = 1.14 (95% CI: 1.07-1.20).

Jun-Jul 2020	combined with the local Rt, mobility data and information on implemented policies. The data was analysed using multivariate regression analyses to explore factors associated with community SARS-CoV-2 transmission control in the USA.	• The odds of transmission control (Rt<1) increased (OR 3.53, 95% CI: 2.03-6.43) for each 10% increase in community mask wearing reported in the survey. • Mask wearing was a robust protective factor towards community transmission control across all analyses. • Community transmission control was predicted to be highest with both high mask wearing and social distancing in place. Where social distancing was low despite high mask use community transmission control dropped to 35%. • The analysis did not find a significant increase in mask usage following mask mandate policy, possible reasons for this were not discussed. • Adherence to mask wearing was highest among women, elderly, non-white or Hispanic ethnic groups and lower income respondents. • Mask wearing was highest along the coast, southern border and in urban areas of the USA.
Cohort studies (n=2)		
Kwon (2020) *preprint* (15) Prospective cohort study USA Mar-Jul 2020	This prospective cohort "COVID symptom study" included participants in the USA using an app from March 29- July 16. Participants provided baseline and health information and were prompted to record health and COVID related information daily. 139,690 participants provided information for the association between self-reported use of a face mask and predicted risk of COVID-19.	• Individuals who reported using a mask in the community (sometimes, most of the time, or always) had an adjusted HR for predicted COVID-19 of 0.35 (95% CI: 0.30-0.42) compared to those that never wore a face mask. • Self-reported masking was associated with a 69%, 71%, and 63% reduced risk of predicted COVID-19 among individuals living in communities with excellent, fair, and poor social distancing, respectively. • The findings provide support for the efficacy of mask-wearing in reducing

	The study used predicted COVID-19 as a proxy for a positive COVID-19 test due to the small number of COVID-19 test positive app users during the study period. Survival analysis adjusted for age, sex, ethnicity, state, smoking, frontline workers and comorbidities.	COVID-19 transmission even in settings of poor social distancing.
Wang (2020) (17) Retrospective cohort study China Feb-Mar 2020	This retrospective cohort study consisted of 335 people in 124 families with at least one laboratory confirmed COVID-19 case in Beijing from Feb 28 - Mar 27, 2020.	• The secondary attack rate in families was 23.0% (77/335). • Face mask use by the primary case and family contacts before the primary case developed symptoms was 79% effective in reducing transmission (OR=0.21, 95% CI: 0.06 to 0.79). • However, wearing a mask after illness onset of the primary case was not significantly protective.
Case-control studies (n=1)		
Doung-ngern (2020) (18) Case-control study Thailand Mar 2020	This retrospective case-control study used contact tracing records in Thailand to establish their sample. 1,050 contacts of COVID-19 patients from Mar 1-31, 2020 were retrospectively interviewed. Cases (n=211) were defined as asymptomatic contacts of COVID-19 patients who later tested positive for SARS-CoV-2 infection and controls (n=839) were asymptomatic contacts who never tested positive.	• Wearing a mask at all times (aOR 0.23, 95% CI: 0.09-0.60) was independently associated with lower risk of COVID-19 infection compared to not wearing masks. However, wearing a mask sometimes (aOR 0.87, 95% CI: 0.41-1.84) was not. • Those that wore masks all the time were more likely to wash hands and practice social distancing.
Cross-sectional studies (n=5)		
Lopez (2020) *preprint* (14) Cross-sectional study	In this study, the SARS-CoV-2 seroprevalence of 753 public school staff was determined and correlations between seropositivity and self-reported histories (e.g.	• The seroprevalence was estimated to be 1.7% (90% CI: 0.27- 3.3). • After controlling for six confounders, the results of the multivariate analysis reveal that self-reported mask-wearing history

	mask wearing) and demographics were analyzed.	reduces the risk of being seropositive (RR 0.83, 95% CI: 0.18-3.8).
USA Jul 2020		
Rodríguez-Barranco (2020) (24) Cross-sectional study Spain Apr-May 2020	This study looked at possible routes of exposure to SARS-CoV-2, risk factors, and the effectiveness of the recommended hygiene measures. Self-reported information was collected from 2086 individuals via online survey.	• 73.4% of individuals wore a mask when they left confinement (34.9% FFP2/FFP3 face mask, 64.4% surgical, and 0.7% homemade mask). • The estimated prevalence of COVID-19 was 4.7% (49 confirmed and 50 suspected cases). • Not taking any other variable into consideration, there was no association between COVID-19 status and mask use (p=0.205): 3.9%, 5.7%, 0%, 3.1%, 5.8% reported having confirmed or suspected COVID-19 of individuals who self-reported wearing an FFP2/FFP3 mask, surgical mask, homemade mask, no mask, and reported not leaving the house respectively.
Payne (2020) (13) Cross-sectional study USA Mar-Apr 2020	A survey of US Navy service members (convenience sample, n=382) linked to a COVID-19 outbreak in an aircraft carrier was conducted to collect information on self-reported face mask use and other protective measures (e.g. avoiding common areas, social distancing). The results were analyzed to determine associations with infection risk. 284 individuals within the sample were found to be positive for SARS-CoV-2 priori to or at the time of serum testing.	• Participants that self-reported wearing a mask (55.8%) had a lower odds of COVID-19 (OR 0.3, 95% CI: 0.2–0.5) compared to those who reported not wearing a mask (80.8%).

Clipman (2020) (16) Cross-sectional study USA Jun 2020	Associations with self-reported SARS-CoV-2 positivity and adoption of NPIs was analyzed using an online survey of 1030 residents in Maryland. Logistic regression was used to identify variables associated with ever testing positive for SARS-CoV-2.	• Of the study sample, 5% (n=55) self reported ever testing positive for SARS-CoV-2. • 53% of participants reported always wearing a mask in indoor and outdoor settings. • A small association between mask wearing (always) and testing positive for SARS-CoV-2 was identified, aOR 0.63 (95% CI: 0.36-1.09).
van den Broek (2020) *preprint* (25) Cross-sectional study USA Apr-Jun 2020	In this study, community residents were surveyed and respondents (n=454) were offered RT-PCR and serological SARS-CoV-2 testing. Multivariate analysis using probit models was conducted to identify associations.	• 2.2% (95% CI: 0.8-3.6%) of the study sample were found to be SARS-CoV-2 positive by serology testing. • Mask wearing outside of work was not statistically different between those that tested positive (0.5%, SE 0.189) vs. negative (0.7%, SE 0.230) for COVID-19.
Cluster and outbreak investigations (n=4)		
Hendrix (2020) (19) Cluster investigation USA May 2020	This retrospective epidemiological investigation analyzed 139 clients that were exposed to 2 hair stylists in Missouri, USA who were infected with SARS-CoV-2. Both clients and hair stylists were wearing face masks.	• Of the 139 clients who were exposed, 67 were tested. • There were no symptomatic secondary cases reported, which was most likely due to the use of face masks.
Cheng (2020) (20) Cluster investigation Hong Kong Jan-Apr 2020	This study describes the findings of cluster investigations in Hong Kong during the first 100 days of the pandemic. The number of COVID-19 clusters involving wearing a mask and not wearing a mask were compared. Hong Kong had initiated a mandatory face mask use policy	• Up to day 100 of the epidemic, 961 cases of COVID-19 cases were confirmed in Hong Kong. Among these cases, 11 clusters of 113 persons were directly engaged in mask-off activities such as dining and drinking in a restaurant or bar, singing at karaoke, and exercise in fitness clubs compared to 3 clusters involving 11

	and adherence was estimated to be 96.6% (95% CI: 95.7 – 97.2%).	persons engaged in mask-on settings at the workplace (Chi square p=0.036).
Hong (2020) (22) Cluster investigation China Jan-Mar 2020	Clinical and epidemiological data were retrospectively retrieved from electronic medical records and valid individual questionnaires from Jan 23-Mar 1, 2020 of 127 patients with COVID-19 in Zhejiang, China.	• Before they were diagnosed, 41 COVID-19 pre-symptomatic patients had close contact with local residents. • 28/41 were wearing masks and had close contact with 123 residents, leading to 10 secondary SARS-CoV-2 infections. • The other 13 who did not wear masks had close contact with 74 residents, leading to 14 secondary SARS-CoV-2 infections. • The percentage of local residents infected with SARS-CoV-2 was significantly lower in the group who came into contact with infected individuals wearing a mask than those who came into contact with infected individuals not wearing a mask (8.1% vs. 19.0%; p < 0.001).
Liu (2020) (21) Outbreak investigation China 2020	This was a retrospective epidemiological investigation of SARS-CoV-2 exposure on public transportation. It described two bus trips in quick succession by an infected and symptomatic individual from Chongqing, the first without a face mask, and the second with a face mask.	• On the bus trip that the infected individual wore a mask, there were no others infected (14 passengers). • On the bus trip that the infected individual did not wear a mask, 5/39 people were infected.
Natural experiment (n=1)		
Pletz (2020) *preprint* (26) Natural experiment Germany Apr 2020	The effects of universal face masks in public settings was compared between two cities close together that had a similar size and community structure. In the implementation of NPIs the city of Jena implemented a face mask policy at the beginning of a 4 week lockdown and Erfurt issued the face	• No new cases of SARS-CoV-2 were observed in Jena 5 days after the implementation of a mandatory face cover policy. • In Erfurt, infections continued to spread within the community during the lockdown period, until community masking was imposed alongside lockdown phase lifting.

mask policy at the end of lockdown. Note: both cloth masks and scarfs were acceptable if mouth and nose were covered.	• The observations may have been caused by other things so conclusions are limited, but it was a unique opportunity to look at the impact of a face mask policy between two similar communities.

CI = confidence interval, HR = hazard ratio, NPI = non-pharmaceutical intervention, OR = odds ratio, Rt = effective reproduction number

ECOLOGICAL STUDIES ASSESSING IMPACT OF POLICIES AND SOCIETAL NORMS

Twenty-seven ecological studies were identified on the impact of face mask recommendations and policies to prevent COVID-19 in community settings (Table 2). All of these studies analyzed aggregate population level data to estimate the impact of face mask polices on reducing COVID-19. A variety of approaches and sensitivity analyses were used across studies and are not detailed here; readers are encouraged to refer to the individual studies for more on their methodology.

- The majority (n=26) of these ecological studies demonstrated that face mask polices were protective against COVID-19, however the magnitude varied across studies.

    o Nine studies associated implementation of community face mask polices showed a range from 3.2-48% decrease in COVID-19 infections (4-7, 9, 27-30).

    o Five studies showed a 17-23% reduction in Rt after the implementation of mask policies. (11, 29, 31-33).

    o In an Ontario study, mask policies resulted in a 25-31% weekly reduction in COVID-19 cases two weeks after implementation (4).

    o Early and late mask policies were both effective in reducing COVID-19 infections as demonstrated in a study from the USA (8).

    o One study that compared mask effectiveness in countries with pre-existing norms compared to countries with no pre-existing mask norm found that in countries where all sick people normally wear masks, there was a lower daily growth rate of COVID-19 cases and deaths (10).

- The only study that did not show the mask policy had a significant impact was one during lock down conditions -1% (95% CI: -13 to 8%) (9).

- One study assessed effectiveness of a universal mask policy by age. Age related COVID-19 case reduction associated with a universal mask policy in New York demonstrated a 20.8% reduction in cases for both 65-74 year olds and 75+ year-olds in the first month, whereas 25-44 and 45-64 year-olds were associated with 4.5% and 8.1%, respectively (5).

- Employee face mask policies were associated with a decrease in COVID-19 infections and deaths across three studies (1, 6, 7). However, this association was not as strong or as consistent across analyses as universal mask policies (7).

- Recommendations for mask use in the community is not as effective as mask policies (1). Implementation of mask policies was shown in two studies to increase mask use by 30-54% (4, 11)

- Adherence to any of the NPIs is critical to success, one study suggested a 75% adherence rate was needed for community mask wearing to be effective and that if adherence was over 85%, social distancing policies had no additional effect on further mitigating the number of COVID-19 cases (34).

Table 2. Ecological studies on the effectiveness of face mask policies and/or societal norms to protect against COVID-19 in community settings (n=27)

STUDY	METHODS	KEY OUTCOMES
Global (n=8)		
Haug (2020) (32) Ecological study Global Mar-Aug 2020	This study aimed to assess the effectiveness of NPIs to mitigate the spread of SARS-CoV-2. Using a coded dataset of 6,068 NPIs implemented in Mar – Apr 2020 in 79 territories, the impact of government interventions on Rt was conducted using four different statistical approaches. Findings were validated using two external datasets recording 42,151 additional NPIs from 226 countries.	• Wearing a mask was associated with a significant impact on Rt by three different methods (ΔRt between −0.018 and −0.12). • Results indicate that a suitable combination of NPIs are necessary to curb the spread of the virus.
Miyazawa (2020) *preprint* (35) Ecological study 22 countries Mar-May 2020	The study aimed to identify the association between mask wearing rate and the cumulative number of deaths caused by COVID-19 across countries. Mask wearing rates were calculated from survey responses during March 9–18 and April 26 – May 1, 2020, respectively.	• In March, the face mask non-wearing rate was positively associated with the cumulative number of deaths (β 0.0048, SE 0.011, adjusted R2 0.680), but not in Apr–May (β 0.0020, SE 0.011, adjusted R2 0.466). • The regression models explained 69% of the variation in the cumulative number of deaths per million among 22 countries and identified the face mask wearing rate in March as an important predictor.
Brauner (2020) *preprint* (9)	In this study, the effectiveness of eight NPIs in 41 countries was	• Under lock down conditions some masking in public did not have a large

Ecological study Global Jan-May 2020	estimated with a Bayesian hierarchical model by linking NPI implementation dates to national case and death counts. They explored mandating mask policies, limiting gatherings <1000 or <100, or <10, closing high-risk businesses, closing non-essential businesses, closing schools and universities and stay at home orders.	impact. The mean proportion reduction with mandating mask-wearing in (some) public places was -1% (95% CI: -13 to 8%). • In this study, mandatory masking policies were implemented after all the other social distancing and school and business closures and the study ended before lifting of these restrictions.
Esra (2020) *preprint* (29) Ecological study Global Jan-May 2020	Using globally reported SARS-CoV-2 cases to fit a Bayesian model framework, this study aimed to estimate transmission associated with NPIs in 26 countries and 34 USA states. NPIs examined include stay home mandates, gathering limits, school closures, and mask policies.	• The mean reduction in Rt in SARS-CoV-2 infections was 17% (95% CI: 6-28%) with mask policies.
Zhang (2020) (36) Ecological study China, Italy, USA Jan-May 2020	This analysis of daily SARS-CoV-2 infection trends Jan 23- May 9 that specifically look at the linear trajectory of COVID-19 cases and changes that occurred after face mask policies were implemented in Italy and NYC.	• Face mask use was estimated to have avoided >75 000 in Italy (from Apr 6 – May 9) and >66 000 infections in NYC (from Apr 17 - May 9). • While other areas of the world show a linear increase, this study showed that the implementation of the mask policies in Italy and NYC reduced the spread of COVID-19.
Leffler (2020) (37) Ecological study 196 countries Jan-May 2020	The impact of masks on per-capita COVID-19 related mortality was investigated using mortality data from 196 countries up to May 9, 2020.	• Duration of mask-wearing by the public had a negative independent association with mortality (all p<0.001). • In countries with cultural norms or government policies supporting public mask-wearing, per-capita coronavirus mortality increased on average by just 16.2% each week, compared with 61.9% each week in remaining countries.

Abaluck (2020) *preprint* (10) Ecological study Global Feb-Mar 2020	This study analyzes the impact of face masks by considering the relationship between norms of face mask use and COVID-19 spread at the country level. Countries with pre-existing norms that all sick people wear masks were compared to countries that do not, but later required masks for infected individuals, and countries with no mask norm and no official mask recommendation. Countries with at least 5 million people with at least 8 days of data available after the first day with 100 reported cases were included.	• Countries with pre-existing norms that sick people should wear masks (South Korea, Japan, Hong Kong, and Taiwan) have been among the most effective countries in containing the spread of the epidemic. • The average daily growth rate of confirmed cases is 18% in countries with no pre-existing mask norms and 10% in countries with such pre-existing norms. • The average daily growth rate of deaths is 21% in countries with no pre-existing mask norms and 11% in countries with such pre-existing norms. • After adjusting for concurrent interventions, the impact of mask norms (β [SE]) was −0.076 [0.030], p<0.05 for cases, and −0.107 [0.024], p<0.01 for deaths.
Kenyon (2020) *preprint* (38) Ecological study 49 countries Jan-Mar 2020	The association between COVID-19 cases and the national promotion of face masks in public was analyzed, controlling for the age of the epidemic and testing intensity. Only countries with at least 500 cumulative cases and whose first case was reported before Mar 7, 2020 were included. 8/49 countries advocated wearing face masks in public (China, Czechia, Hong Kong, Japan, Singapore, South Korea, Thailand, and Malaysia).	• Results of multivariate analysis show face mask use in public had a negative association with the number of COVID-19 cases/inhabitant (β -326, 95% CI: -601 to - 51, P=0.021).
North America (n=13)		
Karaivanov (2020) *preprint* (4)	The impact of NPIs was assessed using publically available data on mask policies in Ontario, other NPIs	• After a 2 week lag, mask policies resulted in a 25-31% weekly reduction in COVID-19 cases.

Ecological study Canada Jul-Aug 2020	in Canada, and the number of COVID-19 cases.	• Mask policies increased mask usage by 30%.
Spiegel (2020) *preprint* (1) Ecological study USA Mar-Oct 2020	This regression analysis looked at the fatality growth due to COVID-19 and the impact of mandatory mask policies across every county in the USA from March to October.	• Mandatory mask policies equate to a 1% lower 4 week and 6 week fatality growth rate compared to no mask policy, $p<0.01$. • Mask policies were effective in every specification of the model and are accompanied by relatively low economic and social costs. This result was both statistically significant and important in magnitude. • Employee mask policies were not consistently protective across all analyses. • Mask recommendations consistently did not have a protective effect on the fatality growth rate.
Shacham (2020) *preprint* (28) Ecological study USA Jun-Sep 2020	This study analyzed the impact of a mask policy implemented in 2 counties of a 5-county metropolitan region on COVID-19 cases over a 3-month period of time.	• County-level mask policies were associated with significantly lower COVID-19 case growth over time compared to neighboring counties that did not implement a mask policy. • Crude modeling with a difference-in-difference indicator showed that after three weeks of mask policy implementation, counties with a mask policy had a daily percent COVID-19 growth rate that was 1.32 times lower (32% decrease) compared to counties without a mask policy. • At 12 weeks post-mask policy implementation, the average daily COVID-19 case growth among counties without a mask policy was 2.42% (±1.92), and was significantly higher than the average daily

		COVID-19 case growth among counties with a mask policy (1.36% (±0.96%)) (p<0.001).
Yilmazuday (2020) *preprint* (34) Ecological study USA Feb-Aug 2020	Using a difference in-difference design, county-level data on changes in COVID-19 cases or deaths were analyzed using social interactions measured by Google mobility. Counties were categorized as mask-wearing vs. non-mask-wearing by using Mask-Wearing Survey Data. The impact of mask wearing on the causal relationship between COVID-19 cases and social interactions was subsequently analyzed.	• Adherence to wearing a face mask in the community needs to exceed 75% to reduce COVID-19 cases and deaths. The effects of social interaction on COVID-19 were statistically eliminated when more than 85% of people in a county "always" wore a face mask in public settings.
Matzinger (2020) *preprint* (8) Ecological study USA Mar-Jul 2020	A regression analysis was conducted to assess the impact of NPIs on COVID-19 cases, hospitalizations, and deaths. Mask policies were implemented between Mar-Jul, allowing for an opportunity to evaluate both early and late policies.	• Regression analysis showed that closing schools, closing bars, and wearing masks had major effects on infections, hospitalizations and death rates in the US during the COVID-19 pandemic. • For four states (IL, NJ, MA, MD), a drop in the rates of infections were observed after implementing a mask policy. Decreased rates were followed by a 2-fold drop in hospitalizations and deaths. • Across the dataset, the mask policies occurred at different times and the authors show the rate reductions followed in a predictable manner. Later policies correlated to later inflection points. This supports the evidence that these rate reductions were due to wearing masks as opposed to other potential changes in mobility or behavior. • The early and late mask policies were both effective in reducing COVID-19 infections.

		• The lag time between the implementation of mask policies to a reduction in COVID-19 infections was between 16-23 days. • One exception to the effect of early mask policies was shown in the data from NY which mandated masks after it had already turned its rapidly rising infection numbers into declining ones. The mask policy had no further suppressive effect on infections. However, when NY later opened its economy and infections began to rise, the increase was remarkably lower than those of states that opened without mask policies in place. This suggests continuing the mask policy had an effect when lifting other NPIs.
Kaufman (2020) (39) Ecological study USA Jan-Jul 2020	This study estimated the excess COVID-19 burden in USA states that had an evidence-based reopening strategy, defined as reopening indoor dining rooms after implementing a statewide masking policy, compared to states that lacked an evidence-based reopening strategy, defined as reopening indoor dining rooms before implementing a statewide masking policy.	• An estimated > 50,000 excess deaths were prevented within 6 weeks in 13 states that implemented mask policies prior to reopening. • In states reopening without mask policies, the number of excess cases per 100,000 residents is ten times the number in states with mask policies 8 weeks after reopening (643.1 cases; 95% CI: 406.9-879.2 vs. 62.9 cases; 95% CI: 12.6-113.1). • Excess cases after 6 weeks could have been reduced by 90% from 576,371 to 63,062 and excess deaths reduced by 80% from 22,851 to 4858 had states implemented mask policies prior to reopening.
Yang (2020) *preprint* (31) Ecological study	This study analyzed county level Rt values over time using a mechanistic meta-population model and associated these with county-level characteristics and NPIs such as school closures,	• The estimated impacts of individual interventions were measured during layered intervention strategies and do not estimate the potential impact if done alone.

USA Jan-Jul 2020	daycare closures, banning nursing home visits, stay home orders, and wearing a face mask. With the exception of the mask policy, the closures were confounded by workplace presence which also decreased at the same time as the closures.	• Face mask policies were associated with an 18% reduction in Rt (95% CI: 16-20%).
Chernozhukov (2020) (6) Ecological study USA Mar-Jun 2020	This study uses case data and information on changes to NPIs to assess the impact on the growth rates of confirmed COVID-19 cases and deaths. The face mask policy in this study is mandating face masks for employees. NPIs examined included stay at home orders, business closures, and school closures.	• The results attribute a 9% reduction in the weekly growth rate and a 15% reduction in the weekly death rate with a 14 day lag time to mandating employees wearing masks, p<0.01. This was stable across several types of analysis.
Maloney (2020) preprint (40) Ecological study USA Mar-Jun 2020	This study used a non-parametric machine learning algorithm to test the hypothesis that mask policies were associated with reductions in new COVID-19 cases. Data on new COVID-19 cases in 38 USA states was analysed in the month before and after the mask policy implementation date.	• All state analysis: The mean overall number of new COVID-19 cases before vs. after the mask policy was 654 (N=1138, SD=1357) vs. 639 (N=1177, SD=975), respectively. 13 states had higher mean case numbers pre vs. post mask policy. • State-wise analysis: With the exception of Georgia and Wyoming, the states with a greater mean pre vs post mask policy achieved statistical significance: strongly to moderately supporting a reduction in COVID-19 cases after implementation of the mask policy in eleven states. • Societal cohesion and close social ties was shown to best predict states where mask policies were successful. They suggest that this represents compliance across different states.
Li (2020) (30)	Analysis of the total infections and daily infections in the top 15	• The analysis finds that despite stay at home orders most states experienced an

Ecological study USA Mar-May 2020	infected USA states was conducted to investigate the impact of NPIs: such as social distancing, stay at home orders and face mask policies (6 states had no face mask orders, 9 states had face mask policies) March 1 to May 18, 2020. Changes in the regression slopes after the implementation of NPIs were measured and compared across states.	upward trend in daily new infections. Eight states experienced a reversed downward trend or slowing trend after face mask policies were introduced. • In contrast, in states where face masks were not mandated the upward trend in cases extended for up to two additional months. • The analysis estimates ~252,000 infections have been avoided across 7 states that introduced mandatory face mask policies with a projected proportion of cases prevented ranging from 3.2% to 48% up to May 18.
Lyu (2020) (7) Ecological study USA Mar-May 2020	This study measured the effects of state government policies for face mask use in the public issued by 15 states (and DC) from Apr 8-May 15, 2020. County-level case data was used from March 31 (seven days before the first state signed a face cover policy) through May 22. Between Apr 17-May 9, 2020, the impact of 20 states mandating that certain employees wear face masks was also assessed.	• There was a significant decline in daily COVID-19 growth rate after mandating face masks in public with the effect increasing over time. • There was a decline in the daily COVID-19 growth rate by 0.9, 1.1, 1.4, 1.7, and 2.0% in 1–5, 6–10, 11–15, 16–20, and 21+ days after implementation of mandatory face mask policies, respectively. • It was estimated that 230,000–450,000 cases may have been averted due to these policies by May 22. • The impact of employee-mandated face mask use was small and not statistically significant.
Yang (2020) *preprint* (5) Ecological study USA	This study used a linear regression accounting for mobility data in NYC to estimate the effectiveness of NPIs for the entire population and by age group.	• Face covering policies resulted in a 6.6% (95% CI: 0.8 - 12.4%) reduction in cases in the first month and a 3.4% reduction (95% CI: -1.9 - 8.6%) across the entire eight weeks of lockdown. • This effect varied by age: 20.8% (95% CI: -0.1-41.6%) for 65-74 year olds and 20.8% (95% CI: -0.9 – 42.5%) for 75+ year olds

Apr 2020		during the first month and remained at similar levels afterwards. For 25-44 and 45-64 year olds the effectiveness was 4.5% (95% CI: -0.6 – 9.7%) and 8.1% (95% CI: -0.1 – 16.1%) in the first month, respectively; however, it reduced substantially afterwards, likely due to reversed risk behavior.
Xu (2020) (41) Ecological study USA Mar-Apr 2020	In this study, the associations of stay-at-home order (SAHO) and face masking recommendation with COVID-19 epidemics were analyzed. The temporal trends in daily new cases and deaths COVID-19 cases and Rt were modeled. The CDC recommended the use of face masks on Apr 3, 2020.	• The overall slope change of daily new deaths face-masking were −0.13 (95% CI: −0.25 to −0.07). • The overall slope change of daily new cases attributable to face-masking were −0.10 (95% CI: −0.18 to −0.08).
Australia (n=1)		
Scott (2020) *preprint* (11) Ecological study Australia Jul-Aug 2020	Due to a resurgence of COVID-19 in Melbourne, a mandatory mask policy was implemented on Jul 22 creating a natural experiment to assess the impact of the policy on the epidemic growth rate as the policy introduction occurred in the absence of other changes to restrictions.	• The introduction of a mandatory mask policy was associated with an estimated 23% reduction in Rt, from 1.18 to 0.91. • The shift in epidemic growth was observed eight days after the policy was introduced which is consistent with the incubation time of COVID-19 plus the time needed to test and report new cases. • Analysis of images of people in public spaces showed mask usage rose from approximately 43% to 97% and survey data found that before policy introduction, 44% of participants reported "often" or "always" wearing a mask; and after, 100% reported "always" doing so.
Europe (n=4)		
Sruthi (2020) *preprint* (33) Ecological study	This study aimed to develop a systematic relation between the degrees of NPIs implemented by the 26 cantons in Switzerland and	• The mask wearing policy on public transport and in secondary schools contributed to a 0.025 (CI: 0.018-0.03)

Switzerland

Mar-Sep 2020 | their respective contributions to Rt. The mask wearing policy was only on public transportation and in secondary schools. | reduction in Rt compared to baseline with no policies.

• When analyzed separately, a reduction of Rt 0.011 (CI: 0.008-0.0127) and 0.0139 (CI: 0.0132-0.0144) was estimated for the use of masks in secondary school and on public transport, respectively.

• Some places added mandatory masks in shops, but no further reduction in Rt was detected. |
Mergel (2020) *preprint* (42) Ecological study Germany Apr-Jul 2020	In this study, the impact of a face mask policy on the daily COVID-19 Rt and fatality rate was investigated. The study also looked at the implementation/lifting of NPIs (mass gathering prohibited, public life restricted, private contacts restricted, face masks in public spaces and easing of lockdown).	• In this study mask wearing was implemented April 27 after all the other restrictions. • It was not possible to separate the potential positive effect of spring and summer on the trajectory of the pandemic from the mask wearing policy that was implemented. • They did not detect an impact on Rt attributable to the mask policy. • During the time the mask policy was implemented, cases became less lethal from 7% on Apr 27 to 1% in July.
Pedersen (2020) *preprint* (43) Ecological study Italy Feb-Jul 2020	To determine which public health measures altered disease dynamics, change points in COVID-19 dynamics were estimated using regional and national data. A change point is an identified time point where there is a shift in the number of daily confirmed cases from the introduction of a public intervention 7–11 days prior.	• In Veneto, a change point was identified on Apr 21 (95% CI: 14 - 28), which corresponds to the policy of mandatory face mask use on Apr 14. • In Tuscany, a change point was identified on Apr 16 (95% CI: 8 – 24), which corresponds to face mask distribution on Apr 7. • The change points in regional COVID-19 cases correlate well with face mask policies.
Mitze (2020) *unpublished* (27)	Using epidemic data from Germany, a synthetic control method was used to assess the	• Ten days after masks became compulsory in Germany, the cumulative number of

Ecological study Germany Jan-May 2020	effect of face masks on the spread of COVID-19. The city of Jena implemented a mandatory face mask policy on Apr 6, 2020. Jena was compared to a synthetic control area that closely followed the COVID-19 trend before the introduction of mandatory masks in Jena.	registered COVID-19 cases were reduced between 2.3-13%. • After the face mask policy, the daily growth rate of reported infections decreased by 18.94%. After taking the treatment effect for larger cities into account, authors conclude there was a reduction in the growth rate of infections by around 40%.
Middle East (n=1)		
Saki (2020) *preprint* (44) Ecological study Iran Jun-Jul 2020	This study investigated the effects of implementing a social distancing policy, and the impact of its lifting, as well as the effects of face mask policies on the temporal trend of new COVID-19 cases. Data was collected both two weeks before and after the implementation of each policy.	• Prior to the implementation of the policy of wearing masks in the community, there were approximately 2491.97 new daily confirmed cases and an upward slope (p<0.001). • With the implementation of the face mask policy, the trend in the number of daily confirmed cases decreased that caused a change in the slope of the epidemic curve -25.84 (p<0.001).

CI = confidence interval, HR = hazard ratio, NPI = non-pharmaceutical intervention, NYC = New York City, OR = odds ratio, Rt = effective reproduction number, SE = standard error

SYNTHESIS RESEARCH ASSESSING EFFECTIVENESS

Six synthesis research reviews were identified on the protective effect of the use of face masks in community settings, including four systematic reviews and two rapid reviews (Table 3). The earliest review was conducted in April 2020. Two of the later reviews included studies published up to early October. A progression of evidence from April to October is discernable in these reviews. Many of the studies in the reviews are considered relevant to this rapid review and are also included in the evidence tables above.

Table 3. Synthesis research on the use of face masks to prevent COVID-19 in community settings (n=6)

STUDY	METHODS	KEY OUTCOMES
Systematic reviews (n=4)		
Li (2020) *preprint* (45) Systematic review and meta-analysis	The purpose of this review was to evaluate the effectiveness of using face masks to protect from SARS-CoV-2 infection. Six case-control studies were included, five on	• Overall, wearing a mask significantly reduced the risk of SARS-CoV-2 infection (MA OR 0.38, 95% CI: 0.21-0.69, I²= 54.1%).

China, India, Thailand, USA Oct 2020	healthcare workers and one on the general population. Review contains literature up until Oct 2020. AMSTAR: high quality Note: Meta-analysis (MA) was conducted. Where I^2, a measure of between study heterogeneity, was > 50% a random effects model was used, otherwise a fixed-effect model was used.	• In a subgroup analysis, healthcare workers wearing a mask had a reduced risk of COVID-19 by ~70% (MA OR 0.29, 95% CI: 0.18-0.44, I^2=11%). • For the single study on the general population, wearing a mask reduced the risk of SARS-CoV-2 infection by ~28% (OR 0.72, 95% CI: 0.46-1.12) and after adjusting for confounders (aOR 0.23, 95% CI: 0.09-0.59) (18). • Studies in China showed a higher protective effect than other countries: China MA OR 0.21, 95% CI: 0.09-0.53, I^2 =26.1% vs. other countries MA OR 0.55, 95% CI: 0.32-0.95, I^2 = 39.3%.
Coclite (2020) (46) Systematic review and meta-analysis China, Hong Kong, Iran, Israel, Italy, Japan, Malaysia, Netherlands, Saudi Arabia, South Korea, Taiwan, UK, USA Apr 2020	This review aimed to summarize the evidence on the effectiveness of face mask use in the community to reduce the spread of disease. Thirty-five studies were included (3 RCTs, 13 predictive models, 10 observation studies, and 9 laboratory experiments). Seven predictive models and one laboratory study were specific to SARS-CoV-2. Review contains literature up until Apr 22, 2020. AMSTAR: high quality	• No observational studies on wearing face masks in the community for reducing the spread of COVID-19 were identified. • Mathematical models indicated a decrease in mortality when the population mask coverage was near-universal, regardless of mask efficacy. • All types of masks might reduce aerosol exposure. However, personal respirators were more efficient than surgical masks, which were more efficient than home-made masks. • RCTs showed a trend towards the protective effect of wearing face masks versus no mask (aOR 0.90, 95% CI: 0.78-1.05), however these results were not significant. Similar findings were reported in observational studies.
Chou (2020) (47) Chou (2020) (update 1) (48)	The effectiveness of N95, surgical, and cloth masks in community and health care settings for preventing respiratory virus infections was	• In the first version and second update of this review, no studies evaluating masks for preventions of SARS-CoV-2 infections in community settings were identified.

Chou (2020) (update 2) (49) Chou (2020) (update 3) (50) Living systematic review China, Thailand, USA Oct 2020	assessed in this living systematic review. Search dates: Original search: 2002 – Jun 2, 2020 Update 1: Jun 2 – July 2, 2020 Update 2: July 3 – Aug 2, 2020 Update 3: Aug 3 – Oct 2, 2020 AMSTAR: moderate-high quality (no *a priori* protocol, quality assessment was not conducted with a formal instrument, sub-optimal reporting e.g. unsure if double reviewers for quality assessment).	• The first update identified a cohort study of 124 households with an index SARS-CoV-2 case and 355 uninfected household contacts. In households where masks were used by at least one family member (including the index case) before the development of symptoms were associated with decreased risk for incident infections (aOR 0.21, 95% CI: 0.06-0.79). There was no association between mask use after illness onset in the index case and risk for SARS-CoV-2 infections in family members (17). • The third update identified a case control study in Thailand. Wearing a mask all of the time versus no use was associated with decreased risk for SARS-CoV-2 infection (aOR 0.23, 95% CI: 0.09-0.60), whereas inconsistent use was not associated with decreased risk (aOR 0.87, 95% CI: 0.41-1.84). Mask type (medical mask only, nonmedical mask only, or both) was not independently associated with risk for SARS-CoV-2 infection (p = 0.54) (18).
Chaabna (2020) (51) Systematic review and meta-analysis Australia, China, France, Germany, Hong Kong, Thailand, USA May 2020	The evidence on the effectiveness of cloth and medical face masks for preventing transmission of respiratory infections in community settings was assessed in this review. Twelve studies were included, only one on SARS-CoV-2. Review contains literature up until May 12, 2020. AMSTAR: low quality (missing an *a priori* protocol, double reviewers, only searched two databases, no formal quality assessment).	• No primary studies on cloth face mask effectiveness to prevent respiratory infection transmission were identified. • The meta-analysis identified that medical face mask use significantly reduced the risk of transmitting respiratory infections (pooled OR=0.66, 95% CI: 0.54-0.81). • One study specific to SARS-CoV-2 was identified. This retrospective cohort study demonstrated medical face masks are effective in reducing SARS-CoV-2 transmission when used before those infected develop symptoms (17).

Rapid reviews (n=2)		
Warkentin (2020) *unpublished* (52) Rapid Review Canada, China, Germany, Israel, Japan, South Africa, Thailand, Uganda, UK, USA Aug 2020	This rapid review aimed to assess the evidence on the impact of community mask use on the susceptibility to and transmission of COVID-19, and how mask use compliance affects mask effectiveness. Thirty-one studies were included (21 primary and 10 models on the effectiveness of masks and 5 on mask compliance). Of the 17 primary studies on the effectiveness of masks, there were 9 ecological studies, 1 cohort study, 1 case-control study, and 6 case report/epi investigations. Literature search included Dec 2019 – Aug 2020. AMSTAR: low quality (missing an *a priori* protocol, double reviewers, and quality assessment).	• There was insufficient evidence to quantify the effectiveness of face mask use. • Overall, mask use within the community reduced the number of COVID-19 cases within a population. • Case reports consistently reported fewer secondary cases when index cases and/or their contacts wore masks. • Modelling studies found that wearing a mask, in conjunction with other mitigation strategies, had the potential to reduce mortality due to COVID-19 and avert a resurgence of cases in places where lockdown measures had already reduced the number of cases. • There were no studies that investigated the impact of face mask use in schools.
The Royal Society (2020) *unpublished* (53) Rapid Review China Jun 2020	This rapid review aimed to evaluate the effectiveness of cloth masks and face coverings for the general public and in health-care settings. This included an international comparison of the timing and introduction of face mask policies in relation to COVID-19. Only one study on SARS-CoV-2 was included. Review contains literature up until Jun 26, 2020. AMSTAR rating: low quality (there are little details on the process of conducting the review: search, screening, assessment or extraction of data/analysis).	• Results revealed that no systematic review and meta-analysis has yet been conducted on the effectiveness of other types of cloth masks beyond surgical masks and N95 respirators. • Empirical and experimental evidence on community mask wearing and/or cloth masks is limited. • One study specific to SARS-CoV-2 was identified. This retrospective cohort study demonstrated medical face masks are effective in reducing SARS-CoV-2 transmission when used before those infected develop symptoms (17). • The meta-analysis was based on non-SARS-CoV-2 literature in the healthcare setting indicated protection afforded by

		gauze or cloth masks (RR=0.46; 95% CI: 0.22-0.97; N=746) and paper masks (RR=0.61; 95% CI: 0.41- 0.90; N=166) compared to no mask.

aOR = adjusted odds ratio, CI = confidence interval, MA = meta analysis, RCT = randomized control trial

Methods

A daily scan of the literature (published and pre-published) is conducted by the Knowledge Synthesis team in the Emerging Science Group, Public Health Agency of Canada. The scan has compiled COVID-19 literature since the beginning of the outbreak and is updated daily. Searches to retrieve relevant COVID-19 literature are conducted in Pubmed, Scopus, BioRxiv, MedRxiv, ArXiv, SSRN, Research Square, and COVID-19 information centers run by Lancet, BMJ, Elsevier, Nature and Wiley. The cumulative scan results are maintained in a Refworks database and an excel list that can be searched. Details on this search strategy are available upon request. From this database and excel list, article titles and summaries will be systematically searched for the following key words: mask* OR (face AND cover*). Each potentially relevant reference was analyzed to confirm its relevance and data was extracted into the review. This review contains research published up until November 19, 2020.

Prepared by: Tricia Corrin, Lisa Waddell, and Chatura Prematunge. Emerging Science Group, PHAC.
phac.emergingsciencesecretariat-secretariatdessciencesemergentes.aspc@canada.ca

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