COVID-19 Scientific Advisory Group Rapid Evidence Brief

Effectiveness of Non-Pharmaceutical Interventions in Reducing COVID-19 Transmission in Communities

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Lay Summary

Background:
Non-pharmaceutical Interventions (NPIs) are actions that people and communities can take to help slow the spread of illnesses like pandemic influenza (flu). NPIs are also known as community mitigation strategies. NPIs have been used since the start of the pandemic as the major strategy to counter surges of transmission and deaths. Although full “lockdowns” are sometimes portrayed as the main measure, a spectrum of strategies appear capable of reducing transmission. The “strictness” of measures also can increase the social and economic burdens for individuals and communities, so public health guidance generally recommends reserving stricter measures for dangerously high transmission situations, particularly when health care strain is present.

Current Situation:
The Delta variant of SARS-CoV-2 has caused a fourth COVID-19 wave in many places, including the currently very severe situation in Alberta (September 2021). Although most of the eligible population has chosen to be vaccinated, a significant proportion remain unvaccinated and there is still insufficient population level immunity to prevent epidemic spread. The health care system in Alberta is currently under extreme strain.

Scientific Literature Review:
To understand which strategies are most effective, researchers have used large datasets where NPI measures have been grouped and assessed for their impact in controlling COVID-19 in different countries over the course of the pandemic. This evidence on how well NPIs reduce spread should be considered in the context of how they were studied; public health measures may differ in details, often were applied together as a “bundle”, and occurred at different points of the epidemic, in different places, so important factors may differ (before or after mass vaccination, difference in predominant SARS-CoV-2 strain, etc).

From the existing evidence, certain measures were more likely to be effective:

- The most effective strategies included gathering size restrictions (including business and restaurant restrictions and social gatherings), event size restrictions, and overall lockdown/stay at home orders which included those measures.
- Moderately useful strategies include masking and symptom screening as a part of “bundles” of interventions, but there is less data supporting that they are effective as single measures.
- Vaccination as a strategy has not been compared to NPIs (the country based NPI data is pre COVID vaccination) but on the basis of effect size and experience in highly vaccinated populations, vaccination is seen as the dominant control measure. However, experience and evidence suggests NPIs will be needed to control transmission until sufficient vaccination rates are reached to provide population protection, and that NPIs can more quickly control a significant pandemic wave.

Overall, the real world evidence of benefit versus risk for vaccination far outweighs evidence for all NPI strategies, which have been assessed only in unimmunized populations. Therefore, application of community wide NPIs would be seen as an emergency measure or a modulating strategy. Given the impact of NPIs or social and economic outcomes, NPI application focused on subgroups at greatest risk that include non fully immunized populations may be an appropriate strategy.

Authorship and Committee Members

Name	Contribution
Lynora Saxinger	Evidence extraction, writing and editing
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Questions or comments about this review can be sent to
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Topic: What is the evidence that supports the various non-pharmaceutical interventions to reduce community spread of COVID-19?

(Rapid evidence brief protocol, interim report)

1. Community masking
2. Business closures and/or restrictions
3. Event size restrictions
4. Municipal workforce policies (e.g., remote work, screening)
5. Restricted access to public spaces for unimmunized individuals
6. Support for unstably housed individuals
7. Messaging strategies to the public
   (additional two topics added by request in revision)
8. Quarantine and Test Trace Isolate
9. "Lockdown" or Stay at Home orders

Context

- A "fourth wave" of COVID-19 is occurring in Alberta and elsewhere, predominantly driven by infections in people who are unvaccinated or partially vaccinated.
- While COVID-19 vaccination is seen as the single most effective strategy to reduce community spread of COVID-19, interim non-pharmaceutical interventions may be required in settings of high transmission during vaccine rollout to both protect healthcare capacity and reduce COVID-19 illness and death, particularly among unvaccinated and vulnerable vaccinated populations.
- Non-pharmaceutical Interventions (NPIs) are actions that people and communities can take to help slow the spread of epidemic or pandemic infections and are also known as community mitigation strategies.
- It is noted that these measures work differently and synergistically, with NPIs decreasing opportunities for transmission, and vaccination decreasing the number of people who are susceptible to infection or to severe outcomes of infection in the population.
- A summary of the current evidence of the effectiveness of these interventions can be valuable to decision makers in various contexts.
- Alberta is experiencing a significant fourth COVID-19 wave driven by the Delta variant, with expected case loads and resultant hospitalizations projected to exceed health care system capacity without population level interventions. Alberta is responsible for 37% of Canadian cases with 1775 daily cases, 75% in non fully vaccinated persons as of September 15, 2021.
- AHS data on VOC related admissions thus far illustrate that suggest 5.2 % of cases require hospitalization (25% of those with ICU admission) and a 0.6% mortality rate in spite of 60% of cases being <65 years old. Illustrating those numbers, with 18421 active cases as of September 15th, we could expect 958 people of that total to at some point require hospitalization, 239 to need critical care, and 110 deaths. Currently in Alberta there are 830 hospitalized cases, 204 in ICU (the highest to date) on September 15, 2021. The most recent reported R value in Alberta (September 5) is 1.12 and thus these numbers are expected to increase.
- There is a strong need to reduce community transmission across Alberta because the health care system will be unable to support this number of COVID-19 patients, and care for patients with other conditions is being severely impacted.
- Non-pharmaceutical intervention(s) with a moderate to high effect have been documented to reduce R by about 1/3 and consequently decrease downstream cases,

hospitalizations and deaths; earlier institution of effective policies can decrease eventual cases by 5-10 fold.

Key Messages from the Evidence Summary and Discussion

- The evidence base for community mitigation strategies/non pharmaceutical interventions (NPI) is largely derived from analyses of country level responses during the first wave of COVID-19.
- The data on NPI effectiveness is largely inferential, from retrospective, observational data drawn from observations of control measures and their effects implemented during the first wave of COVID-19 across many countries, with a variety of definitions, groupings of the measures and methods used to try to separate out effects of specific interventions when they were generally applied in simultaneous and stepwise combinations. Therefore, transmission reduction estimates should not be considered precise.
- Various analyses appear to give reasonably consistent results that suggest that business closures/ restrictions and event size limits likely offer larger effects in reducing transmission than other listed interventions. Lockdown or stay at home order effectiveness was extremely high, but when assessed as an added measure to other NPIs such as event and business restrictions has a small to modest effect. Quarantine is assessed as having a small to moderate effect.
- The evidence on community masking, income support, test and trace, and messaging strategies is more variable in these comparisons but are also well supported overall– for example, masking is commonly recommended as part of layered prevention, though the effectiveness of masks generally is seen to be greater in observational studies compared with controlled studies. The two community masking RCTs (one in preprint) used different masks (cloth and medical) and methods (randomized communities/ assessed community transmission, versus randomized individuals/assessed personal protection) Test and trace is noted to increase case numbers through case finding so ranking of effectiveness is impacted.
- The overall effectiveness of messaging strategies (eg: coordinated public health campaigns) is variable as the content and context vary. Public messaging is an essential part of implementation of any measures, and resources around optimal messaging are available from a variety of sources including the US National Institutes of Health and the World Health Organization.
- Specific interventions to support unstably housed individuals are not specifically evaluated in the NPI ranking literature but government assistance to vulnerable populations is ranked as having a moderate effect. Evidence based measures to address high risk in this group includes management of risk in congregate settings, provision of isolation quarters, and separate housing.
- Restricted access to public spaces for unimmunized individuals is a strategy used in various jurisdictions that appears to increase vaccination uptake. The measured impact on observed infection rates using this strategy is not yet available.
- Key protective measures such as hand hygiene and physical distancing are recommended for all during periods of higher COVID activity to reduce transmission risk and because a proportion of immunized people may be infected, although the risk of severe COVID-19 is reduced.
- It is noted that the benefit of interventions to reduce transmission has been measured prior to availability of COVID-19 vaccines, so the absolute magnitude of benefit reported would be expected to be greater in unimmunized populations. This could support

implementation of restrictions differently in fully immunized and non fully immunized populations.

- Operational and policy considerations including suggested public health measures by levels of community transmission, and the importance of regional/local context are briefly summarized

Table 1. Summary of key messages by element evaluated

Intervention	Summary of Key Messages
Community Masking	Evidence on community masking in observational studies (low quality study design) reports a range of small to large effects; based on this evidence it is broadly supported as a key element of a bundle of interventions to reduce community transmission. A published RCT and preprint RCTs (higher quality study design) are consistent with a possible modest impact, using standard quality cloth masks and medical masks respectively.
Business closure and/or restrictions	Small to moderate effect: targeted closure of "face to face" businesses with a large risk of infection (restaurants and bars) Moderate effect: closing most nonessential businesses delivering personal services Moderate to larger effect: Closure of high risk businesses/settings (eg. full-service restaurants (highest risk), hotels and motels, fitness centres, cafes and snack bars, limited-service restaurants, and religious gatherings)
Event size restrictions	Large effect of restricting to <10 people Moderate to large effect of restricting to <100 people Small to moderate effect of restricting to <1000 These data would pertain to the number of unimmunized people as the studies encompassed the pre-vaccine period.
Workforce policies (work from home, screening)	Moderate-large effect of work from home (similar to event size restrictions) Lack of outcome data on lab test based screening. Some evidence that temperature based screening has no significant affect. Symptom screening is the most common measure implemented and while it can identify infection and is generally supported, outcome data is limited.
Restricted access to public spaces for unimmunized individuals	The magnitude of effect of all other NPIs is derived from unimmunized settings - the anticipated absolute benefit is larger in unimmunized persons, which would generally support application of measures by immune status. Implementation of measures that apply to unimmunized have been observed to increase vaccine uptake; population wide vaccination is the single most effective public health intervention outside complete stringent lockdown.
Support for unstably housed individuals	Moderate effect of government assistance to vulnerable populations. For homeless populations, management of risk in congregate settings and provision of separate housing may significantly (large effect size) reduce the burden of illness and hospitalization in this group.

Messaging strategies to the public	Small to large effect of coordinated public information campaigns (suggesting different effects in different populations) Moderate effect of specific communication of guidelines and work safety protocols to managers and healthcare professionals
Quarantine, and test trace isolate	Small to moderate effect of quarantine / self isolation policies. Variable effect of test and trace interventions, the benefit of which may be obscured as this intervention results in case finding and increases in case numbers in the short term, when implemented in analysed data sets.
Lockdown (Stay at home orders)	Small to very large effects depending on whether assessed as a single measure (very large effect) or in addition to other NPIs (small additional effect.) May be effective on a community rather than national basis in one study. After initial lockdown, effectiveness of prolonged or repeated lockdowns may be less, related to population adherence.

Where numbers are given in the resource documents, the categories of effect sizes are: low effect size =reduction in the reproduction number R of <17.5%, moderate = 17.5 to 35%, large >35%

Methodological Approach to this Review, and Summary of Evidence Reviewed:
Given the timelines required for this rapid brief, we used a pragmatic approach including a targeted search for reviews, meta-analyses, and systematic reviews of the evidence on impact of the listed NPIs to control COVID-19 transmission. This includes a variety of measures that differ in scope. A quality of evidence hierarchy was used, prioritizing evidence based on trials, and analysis of real world outcomes over modelling and laboratory based data in this brief.

A major limitation in determining an absolute effect of an individual NPI strategy is that these measures have generally been applied in a bundle of interventions, at various points of COVID-19 epidemic trajectories in very different communities and contexts. There is variability in population uptake and adherence to measures, and in the definitions of types of NPIs. The effectiveness of individual NPI measures are modelled and estimated using large multi country data sets. Estimates of effects of individual measures may vary significantly between studies, and consideration of the generalizability to the Alberta context is required. However, studies using multiple data sets and methods appear to support a set of fairly consistent core measures.

Background: Overall ranking of multiple interventions:
A validated modelling approach by Haug et al. (2020) using three datasets and four methods on data from the first COVID-19 wave found consensus on the most efficient “curve flattening” interventions; these interventions were 1) restrictions on places where people gather for an extended period of time (closures of shops, restaurants, gatherings of 50 persons or fewer, mandatory home working) and 2) mass gathering cancellation, which were associated with one third reduction in transmission (R value reduction of more than 30% in aggregate.)

A similar analysis of multiple interventions identified workplace closures, income support and debt relief as the most effective NPIs but reported a similar drop in transmission for event size and business restrictions (Liu et al, 2021).

As noted the data on NPI effectiveness is largely inferential, from retrospective, observational data drawn from observations of control measures and their effects implemented during the first wave of COVID-19 across many countries, with a variety of definitions, groupings of the measures and methods used to try to separate out effects of specific interventions when they

were generally applied in simultaneous and stepwise combinations. Therefore, transmission reduction estimates should not be considered precise.

Table 2. Average relative effect of select measures – from Haug et al (2020)

Interventions (example)	**Relative Reduction in Rt***
Small gathering cancellation (closures of shops, restaurants, gatherings of 50 persons or fewer, mandatory home working)	–0.35
Individual movement restrictions (curfew, national lockdown)	–0.13
Mass gathering cancellation (cancellation of a recreational or commercial event)	–0.33
Educate and actively communicate with the public	–0.18
The government provides assistance to vulnerable populations	–0.17

** transmission reduction observed across jurisdictions in first wave, effectiveness could be impacted by current differences in conditions and expected population adherence*

1. Community masking

The Public Health Agency of Canada and the World Health Organization (WHO) advise the use of masks as part of a comprehensive package of prevention and control measures to limit the spread of SARS-CoV-2, the virus that causes COVID-19. High quality studies are few, and previous observational evidence supported community masking as part of a bundle of interventions, with lab based data suggesting face coverings may reduce spread of virus from infected people. Trial data had suggested at best a modest reduction on acute respiratory virus transmission but population observational studies tend to suggest a more substantial effect. Mendez-Brito et al (2021) described variability in the observational data with three intermediate and high-quality studies concluding masking is among the most effective measure, with one analysis suggesting the effectiveness increased when they were mandated for all public places in all geographical areas within a country.

Two new randomized controlled trials (higher quality trial design) of community masking for COVID-19 have been reported since the last SAG update. Both occurred before vaccine implementation. A preprint which has not yet been peer reviewed and published describes a community level randomized trial (cluster RCT) in Bangladesh. This study has a complex design, with an intervention designed to increase mask use but assessing an outcome of effect of masking on infection rates. Communities were observed (control), or provided cloth or surgical masks with varying community incentive/ support/ education programs (intervention) (Abaluck et al, preprint). Observed mask wearing was 42% in the intervention communities versus 13% in control villages (with mask adherence dropping over time). The outcome was not assessed in all participants which may introduce bias. Seropositivity in those reporting any symptoms was 0.76% (control) versus 0.69% (masked) communities, a 9.3% relative reduction reported as statistically significant. This a small effect size, indicating a difference of 15 cases in a population of 32000, but was observed over a short time period and with a small difference in masking between groups (difference of 29%). Greater benefit was seen in communities with surgical over cloth masks, with a larger effect in reducing seropositivity in those >65. Results may be influenced by study design; only those with stated symptoms were asked to have blood testing for COVID, with only 40% tested. In addition, villages were also randomized to “moral” and monetary incentives to encourage mask use which may have dissuaded some symptom reporting, the results may be compromised. This study examined community based mask use and so would potentially encompass both individual protection and source control benefit. However, the observed impact may be influenced by a variety of factors (including degree of

adherence to the intervention). Further examination of the details of this study upon full publication is suggested.

A randomized community masking trial examining how masks may impact individual risk (rather than examining source control/community spread as in the above study) was conducted in Denmark (DANMASK-19; Bungaard et al., 2021) and followed individuals provided with surgical masks for 1 month. Of 4862 participants 42 of 2392 (1.8%) developed COVID-19 in the intervention arm and 53 of 2470 (2.1%) in the control group. This study started under some NPI restrictions and followed some participants through reopening, starting slightly before their initial peak and during the decline of cases. The between-group difference was −0.3% (95% CI, −1.2 to 0.4%; *P* = 0.38) (odds ratio, 0.82 [CI, 0.54 to 1.23]; *P* = 0.33). The study was powered to detect a 50% reduction in infection in mask wearers; as such the results indicated that masks did not provide >50% protection against SARS-CoV-2 infection (in a setting of 2% population incidence monthly), but cannot exclude a benefit that is <50% (the confidence intervals are compatible with a possible 46% reduction to 23% increase in infection among mask wearers).

The type of mask use recommended varies across jurisdictions, a medical mask or high quality cloth mask are most commonly suggested; higher quality masks (medical) were found to be effective in the preprint cluster RCT (reported above) whereas cloth masks were not. Respirator masks (N95, FFP2, KN95 and others) have been increasingly discussed however there is no direct evidence of additional benefit in reducing COVID-19 in healthcare (see SAG review) and there are no studies of respirator masks in community settings. Ecologic data does not suggest a strong effect; mandated public FFP2 masking in Austria from January-July 2021 did not prevent a significant third wave with higher per capita infection rates than adjacent countries without that mandate.

In total, community mask mandates are a common and reasonable measure in situations of high transmission, with current evidence supporting potential protection of the wearer (one study powered to show a 50% or greater reduction in infection did not show significance, so results support a possible <50% reduction is possible) and a preprint report of a community based trial reporting a 9% reduction in tested symptomatic people in communities randomized to a mask intervention, in a setting of overall low prevalence.

2. *Business closure and/or restrictions*

Literature on different levels of business closure was assessed in a systematic review by Mendez-Brito et al (2021) with one preprint analysis showing no additional value to closing all non-essential services in comparison to initial mandatory closure of selected businesses, which in most countries included “non essential” businesses such as restaurants, malls, stores, and theatres. Brauner et al (2021) found that targeted closures of face-to-face businesses with a high risk of infection, such as restaurants, bars, and nightclubs, had a small-to-moderate effect (31% decrease in R). Closing most nonessential businesses delivering personal services was somewhat more effective (40%, moderate effect). When these interventions were already in place, issuing a stay-at-home order had only a small additional effect.

In terms of relative risk of COVID-19 transmission at various public locations, a very detailed mobility network analysis of 98 million people in the US informed a well performing model that suggested that ‘superspreader’ points of interest may account for a large majority of infections, and that restricting the maximum occupancy at each point of interest is potentially more effective than uniformly reducing mobility (Chang et al., 2021). This study did not examine workplace closure and pertains to an unimmunized population. Highest risk points of interest (>100 extra infections per 100,000) included full-service restaurants, fitness centres, cafes and

snack bars, hotels and motels, limited-service restaurants, and religious gatherings, with full service restaurants significantly higher risk even across income strata (associated with >500 to >1500 additional infections per 100,000). Upon reopening, reducing maximum occupancy is predicted to limit infections (example, in this model, capping at 20% of the maximum occupancy in the Chicago metro area reduced the predicted number of new infections by more than 80% with only a 42% reduction in overall customer throughput)

3. *Event size restrictions*

A systematic review by Mendez-Brito et al (2021) notes that definitions in these studies vary (the definition of social gathering restrictions ranged from mass gathering bans to banning gatherings of less than ten people.) While mass gathering bans were associated with a reduction of incidence-related outcomes in 7 out of 14 studies (50%), social gathering bans were associated with a reduction in 11 out of 15 (73%). In higher and intermediate quality studies, restrictions of smaller social gatherings were consistently found to be more effective than restrictions of very large gatherings, with one source suggesting restrictions on gatherings of more than 1000 people were not effective (Liu et al, 2021).

In an analysis of the effectiveness of NPIs across 41 countries in the first wave by Brauner et al (2021), banning gatherings was effective with a large effect size for limiting gatherings to 10 people or less, a moderate-to-large effect for 100 people or less, and a small-to-moderate effect for 1000 people or less: they estimated a 36% and 21% reduction in the reproduction number when limiting gatherings to 10 people or less, and to 100 people or less, respectively.

4. *Municipal workforce policies (e.g., remote work, screening, vaccination)*

Remote Work: It is noted that stay at home orders and workforce policies are overlapping terms in the literature. Brauner et al (2021) noted that recommended workplace closures or staying at home had been effective, implying that voluntary physical distancing has played an important role with differences in the assessment of whether there are improved outcomes, when all–but-essential workplaces were closed. Work from home is also sometimes defined as “small. Gathering cancellation.)

Analysis of a novel crowdsourced US data set by Ebrahim et al (2020) at the level of US counties showed a strong positive correlation between nonessential workplace closure and shelter-in-place orders at the county level, with increased rates 2-6 weeks after the end of workplace closure. There was variability between policies in adjacent counties and across states but the correlation between periods of work closure and reduced transmission was consistent suggesting smaller regional area policies can reduce local transmission. Thus workplace closure (with the practical implication that remote work or income support for affected workers is maintained) appears to be evidence based.

Workplace Screening:
Workplace screening policies can involve different screening modalities.

- Symptom screening may predict COVID-19 infection but resulting transmission reduction has not been demonstrated. However, this measure is routinely employed and transmission rates of COVID-19 are higher when the source individual has symptoms (Cevik et al, 2020). In nursing home settings, symptom- or temperature-based screening and single point-prevalence testing were found to be ineffective (Dykgraaf et al, 2021).
- Workplace Rapid Testing: Mass testing has been suggested as a method of case identification, although few workplace studies were found. A study from Catalonia suggested twice weekly use of PCR and rapid tests identified cases and was modelled to be cost

saving to the healthcare system. Some employers, including the Universities of Alberta, Calgary, and Lethbridge are implementing regular rapid testing for those who have not disclosed that they are fully vaccinated. Modelling studies support a benefit in at least twice weekly testing to reduce transmission in closed settings, but importantly, real world outcome data on such programs is limited, and outbreaks in spite of same day full group rapid tests have been reported. Importantly, existing data and models pertain to unimmunized populations and may not be relevant to immunized populations. Therefore, rapid testing in workplaces offers uncertain benefit and may be best considered as part of a pilot program focused on closed group settings with unimmunized individuals, with outcomes assessment. For more details about rapid testing, see the recent Scientific Advisory Group review of rapid testing.

- Workplace Immunization Policies: Employer stipulated vaccination policies have been employed prior to COVID-19 and in many jurisdictions during COVID-19 vaccine rollout. COVID-19 vaccine safety is excellent and effectiveness is very high; effectiveness against developing COVID-19 symptomatic infection, and reducing transmission is high enough that among completely vaccinated groups and settings where they congregate, most public health bodies suggest restrictions are not necessary. Further data around transmission after vaccination and in completely vaccinated settings would potentially alter this guidance and this is reviewed in an ongoing fashion. Guidance regarding possible medical exemptions to vaccination exists. (See also “restricted access to public space for unimmunized individuals” section below.)

In total the evidence in this area was of low quality. There is a lack of evidence of benefit for temperature screening and specific laboratory screening protocols in workplaces, and some theoretical benefit for symptom screening processes as an adjunctive measure (especially in the setting of low vaccination rates) although asymptomatic transmission has been well described and “layered prevention” is suggested. The role of rapid testing in workplaces is also an area of rapidly evolving evidence, with no current consensus (see upcoming SAG review for more information).

The weight of current evidence and public health experience would support workforce vaccination and remote work as the most effective measures, with reasonable support for symptom screening in identifying infection, and limited outcomes evidence of benefit from rapid testing programs which, if implemented, should be assessed by ongoing outcome tracking.

5. Restricted access to public spaces for unimmunized individuals

This measure has been recently suggested in various Canadian jurisdictions, with a more mature example from the UK, where the NHS COVID Pass is a tool which shows proof of vaccination, a recent negative test, or post documented infection status as a means of entry. The UK government is urging nightclubs and other higher-risk venues with large crowds to make use of this measure, which is presently voluntary.

There is literature on vaccine mandates, which may be somewhat relevant to policies of exclusion of nonimmune individuals from certain spaces. Most of the literature identified was pre COVID-19. Historically, smallpox vaccine mandates resulted in a 20 fold difference in small pox case rates in the early 1900s (Batniji (2021). D’Ancona et al (2019) reported that vaccine coverage in Italy increased from 87.3% to >95% for measles vaccine after expansion of a compulsory vaccine program in 2017. Similarly, Levy-Bruhl et al (2019) reported that mandates on childhood vaccination in France increased coverage of specific vaccines by as much as 36.4% (range 1.4-36.4% increase.) An analysis of US states with a varicella vaccine mandate suggested a 20% increase (Abrevaya & Mulligan, 2011). Various jurisdictions have made

COVID-19 vaccine compulsory for health care workers (health organizations in North America including AHS, BC and Ontario; France and Greece [Wise, 2021]). Sprengholz and Betsch (2020) assessed the effect of mandates on intention to vaccinate, and selective mandates had no overall effect on intentions although the specific content of communication did alter the response of those surveyed: herd immunity communication generally increased vaccination intentions. Selective mandates led to increased anger when herd immunity was not explained, leading in turn to lower subsequent vaccination intentions.

Current modelling in Canada and elsewhere suggest that more transmissible Variants of Concern such as the Delta variant will require a higher proportion of the population to be non-susceptible (infection survivors, vaccinated individuals) to control community transmission of COVID-19 (Liu et al, preprint), and the increased importance of two doses for full protection (Lopez Bernal et al, 2021). Although Alberta has reached its initial target of 70% of eligible persons vaccinated, exponential growth of both cases and hospitalizations is ongoing as of September 13th and vaccination uptake must be maximized. Community level correlation of vaccination and transmission reduction has been demonstrated: communities with higher vaccination rates showed reduced transmission to unvaccinated individuals, mostly children, in a study by Milman et al., (2021) in which each 20 percentage points of vaccinated individuals in a community reduced the positive test fraction for unvaccinated individuals approximately twofold.

Most recently, provinces (Ontario and BC) that introduced demonstration of immunity programs (e.g. vaccination passports) to allow access to certain venues have seen a significant increase in vaccine appointments, particularly in younger eligible age groups. Although some immunization certification programs allow for a recent negative laboratory test (UK COVID pass) there is no outcome information on that provision and epidemiologic data showing large risk of transmission prior to symptoms, and outbreaks reported in fully tested cohorts in sports and suggest some risk. In addition, the degree of transmission risk reduction from vaccination is under ongoing review and most public health bodies recommend continued precautions in high risk spaces.

6. *Support for unstably housed individuals*

A study from Toronto showed homeless people were more likely to test positive for COVID-19 (15.4% versus 6.7%) than stably housed individuals with an adjusted OR of 2.4 (Kiran et al, 2021). A study from Paris suggested congregate setting and overcrowding increased risk by about three times (Bagget & Gaeta, 2021). A modelling study (Lewer et al, 2020) from the UK estimated that a residential intervention (supportive accommodation) would decrease deaths, hospitalizations, and ICU admission in this population by 45%, 64%, and 44% respectively. In a modelling study by Baggett et al (2020), daily symptom screening with testing of screen-positive individuals, paired with non-hospital care site management of people with mild to moderate COVID-19, substantially reduced infections and lowered costs; adding periodic universal screening by virologic testing improved clinical outcomes, as did the addition of temporary housing. A report from the Royal Society (Turnbull et al, 2021) suggested a number of recommendations including centrally coordinated regional responses, reduction of overcrowding with temporary housing, creation of isolation sites, and developing an immunization strategy for homeless populations.

7. *Messaging strategies to the public*

In a systematic review, Mendez-Brito et al (2021) reported that six out of eight studies (75%) analysing public information campaigns found an association with the outcomes of interest with one paper finding a coordinated public information campaign the most impactful measure.

However, 2 of the reviewed papers (Liu et al, 2021, and Haug et al, 2020) found public information campaigns to be among the least effective policies comparatively, suggesting variation exists in this finding across different populations and settings. However, Haug et al (2020) also found that risk-communication strategies feature prominently amongst consensus NPIs - this includes government actions intended to educate and actively communicate with the public. In this review the effective messages included: encouraging people to stay at home, promoting social distancing and workplace safety measures, encouraging the self-initiated isolation of people with symptoms, travel warnings and information campaigns (mostly via social media). Although it varies between settings, public communication on the importance of social distancing has in some settings been only marginally less effective than imposing distancing measures by law. The publication of guidelines and work safety protocols to managers and healthcare professionals was also associated with a small (-0.13) reduction in Rt in 2 analyses of 4 and was influenced by national context. The effectiveness of measures varied by country and by timing of implementation. Overall, public messaging is an essential part of implementation of any measures, and resources around optimal messaging are available from a variety of sources including the US National Institutes of Health and the World Health Organization.

8. *Quarantine, and Test Trace (TT) measures*

This strategy was added after the initial literature search had been performed, so was assessed through the studies that were identified with the overall literature search for the other NPIs. This section will be expanded in future updates.

The evidence for "Quarantine" as a strategy was separately assessed in most studies. Using a strategy of Quarantine within a population was assessed as reducing transmission with an R reduction of 0.11 in Bo et al (2021) and 0.28 in Haug et al (2020) (by 3 of 4 methods), suggesting a small to moderate effect size. In some analyses acute case notification and tracking and testing affected transmission by 5% and 10-15% respectively. Mendez Brito et al (2021) noted that testing and tracing may transiently increase case numbers when implemented (by increased case finding) so this may affect how these measures are assessed in a comparison which does not evaluate downstream infections.

9. *Lockdown- Stay at Home Orders*

In the first wave, "lockdown", or stay at home orders were the most stringent measure to stop community transmission. In the initial Wuhan outbreak, a stringent lockdown dropped the R value from over 3 prior to January 6 2020 to below 1.0 on February 6, below 0.3 on March 1, 2020 (Pan et al, 2020). Looking across countries with varying degrees of stringency, lockdown was ranked as a consensus NPI in Haug et al (2020) with an R reduction of 0.14, found effective in 3 analyses. Brauner found lockdown /stay at home orders as a measure had a small effect size when other NPIs were already in place (approximately 12% additional R reduction) but analyses by Flaxman and Hsiang included these measures in their assessment of lockdown and showed a large effect size.

An economic lens on lockdown effectiveness analysis by Goldstein et al (2021) suggested that restrictions applied for a long period or reintroduced late in the pandemic (for example, in the event of a resurgence of cases) may exert a weaker, attenuated effect on the circulation of the virus and the number of casualties related to population lockdown fatigue.

Finally, a preprint study assessed the effectiveness of community level, local lockdowns in Chile, with the effectiveness of local lockdowns highly affected by the duration of the local lockdown and the level of spillover from neighboring municipalities under different control

measures (Li et al, 2020). In three municipalities a local lockdown lasting 3-weeks longer would have reduced cases by 33-62% in that time period. Better results of municipal level lockdowns would be expected from geographically isolated municipalities without shared transmission networks, or if neighboring municipalities also extend their local lockdowns.

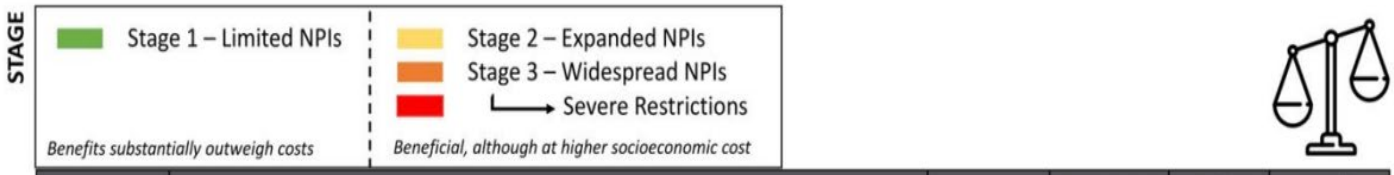
Additional Resources: Operational and policy evidence

The WHO has guidance around selection of optimal policy measures for national and subnational governments.

In this document, a rubric that evaluates effectiveness, socioeconomic cost and public acceptance is presented, where benefit outweighs risk but higher costs to measures supports their use in higher transmission settings (see Table 3 below):

- Lowest socioeconomic costs: teleworking, cohorting, limiting LTC visitation (this would be less relevant post vaccine)
- Intermediate socioeconomic costs: social gathering limits, altering school contacts, minimizing workplace exposures, limit nonessential travel
- Higher socioeconomic costs – beneficial in high transmission: close high risk businesses, schools, travel restrictions
- Highest socioeconomic costs: lockdown (prohibit all movement, only essential services open)

Table 3 [from WHO guidance]: Tool #2: Assessment and categorization of NPIs for implementation of Track 2



Category	Examples of NPIs	Effectiveness	Socioeconomic Cost	Public Acceptance	Overall Assessment*
Workplaces	Teleworking, if possible	✓✓	X	✓✓✓	Stage 1
	Staggering work shifts to decrease contact	✓✓	XX	✓✓	Stage 2
Schools	Classroom and activity cohorting to minimize exposure	✓	X	✓✓✓	Stage 1
	Alterations to school days (hybrid learning arrangements, limit extracurricular activities)	✓	X	✓✓	Stage 2
	Close schools and universities	✓✓	XXX	✓	Stage 3
Public venues and events	Close businesses (except for essential services)	✓✓✓	XXXXX	✓	Stage 3
	Prohibit mass gatherings and/or limit size of social gatherings	✓✓✓	XXX	✓✓	Stage 2
	Close all venues based on the 3C principles, such as bars, sports clubs, entertainment, etc.	✓✓✓	XXXX	✓	Stage 3
	Limit visitations to long-term care facilities	✓✓✓	X	✓✓	Stage 1
Travel	Lockdown affected areas or communities (prohibit movement to/from and within)	✓✓✓	XXXXX	✓	Stage 3
	Postpone travel outside the area for all nonessential travel	✓✓	XXX	✓✓	Stage 2
	Restrict travel from and to affected countries	✓✓	XXXX	✓	Stage 3

* Based on the simple calculation: number of ✓ minus number of X

Threshold and Timing for NPIs:

- The World Health Organization has provided guidance for implementation of health and social measures, based on local epidemiologic indicators. In the WHO Community Transmission (CT) classification system, Alberta data through the week of September 6th ranks as CT 2 for the weekly hospitalizations per capita (9/100,000), CT 3 for percent positivity of COVID-19 tests (13%), and CT 4 (185/100,000) for new case incidence. As these classifications were derived prior to circulation of VOCs with higher hospitalization and ICU risk, it would be reasonable to consider current Alberta epidemiology at a CT3-CT4 range of severity (see table 4 below).

Table 4: WHO: Suggested measures by level of community transmission

Situational Level 3: Community transmission with limited additional capacity to respond and a risk of health services becoming overwhelmed. A larger combination of measures may need to be put in place to limit transmission, manage cases, and ensure epidemic control.	At this level, a strengthening of all PHSM is needed to avoid more stringent restrictions on movement and other related measures applied under level 4. All individuals should reduce their social contacts, and some activities may need to close while allowing for essential services and in particular schools to remain open. In addition to measures on emergency preparedness and response and surveillance, individual precautionary measures and risk communications, authorities may consider implementing the following measures: • Closure of non-essential businesses or remote working as much as possible. • Individual should apply individual precautionary measures and behaviours such as hand hygiene, cough etiquette, staying home if unwell, wearing a mask where appropriate, physical distancing and avoiding the '3C's' – closed spaces, crowded places and close-contact settings. • Consider limiting in-person university teaching, and institute e-learning. • Childcare services and primary and secondary schools should remain open with adequate safety and surveillance measures in place as long as the local context allows. Continuity of education for children for their overall well-being, health and safety should be at the forefront of all relevant considerations and decisions. • Evaluate holding sporting and similar events, using a risk based approach; if held, they should be held under strict safety rules, e.g. without spectators. Other mass gatherings should be suspended, and the size of all social gatherings should be decreased.
Situational Level 4: An uncontrolled epidemic with limited or no additional health system response capacity available, thus requiring extensive measures to avoid overwhelming of health services and substantial excess morbidity and mortality.	At this level, reducing transmission in the community will be challenging, and more stringent movement restrictions and related measures may need to be put in place to significantly reduce the number of in-person encounters. Such measures should geographically limited to where needed, be time-bound and aimed to be as short as reasonably possible. In addition to measures on emergency preparedness and response and surveillance, individual precautionary measures and risk communications, authorities may consider implementing the following measures: • Individuals should stay at home and limit social contact with people outside the household. • Essential workers will need to continue activities, with maximum support and safety measures in place. • Closure of non-essential businesses or remote working. • Consider all options for continuity of in-person learning. If not possible, limit in-person contact. This may include in person teaching, blended or remote learning strategies that strictly limit the number of people physically on site (exceptions would include children of essential workers and their teachers). The closure of educational facilities should only be considered when there are no other alternatives. • All long-term care and other residential facilities should consider strict measures to limit the risk of infection, such as prohibiting in-person visitors.

*The specific measures implemented at each level will need to be carefully considered based on the guiding principles outlined above. The measures at each level are indicative, since some measures may be more or less feasible or appropriate in specific contexts and locations.

- The CDC has a ranking system for community transmission risk however specific epidemiologic thresholds and actions are not delineated.
- PHAC has some guidance for community settings to allow a risk assessment by operators which might be shared within local communities
- Public Health England has issued guidance that includes examples of local and regional level actions. This includes contingency plans for reimposing economic and social restrictions at a local, regional or national level if evidence suggests they are necessary to

suppress or manage a dangerous variant. Such measures would only be re-introduced as a "last resort to prevent unsustainable pressure on the National Health Service." Regulations which enable local authorities to impose restrictions, requirements or prohibitions on individual premises, events and public outdoor places have been maintained.

- Timing of implementation is important. Earlier implementation makes a significant difference during the early growth phase of the pandemic, with one modelling study showing that adopting non essential business closures 1 day earlier lowers COVID-19 deaths by 0.7% (Amuedo-Dorantes, Kaushal, & Muchow, 2021). In this study, responding early slowed spread and prevented overburdening of the health care system.

Description of voluntary Public Health England guidance: strong encouragement for venue check in, minimising the number, proximity and duration of social contacts, encouraging and supporting businesses and large events to use the NHS COVID Pass in high-risk settings to help to limit the risk of infection.
Additional support is planned for local areas facing sharply rising levels of transmission, with priority access to the following:

- targeted surge testing, usually with LFDs (lateral flow devices) at locations within the local authority area
- vaccination logistical support, including extended opening hours and community outreach
- logistics support to help coordinate a ground campaign, for example door knocking in key neighbourhoods to support the response
- onsite testing in educational settings, and discretion to work with secondary schools and colleges on the proportionate temporary reintroduction of face coverings.
- communications support, including national funding to enhance local communications efforts

The UK guidance also suggests actions for specific areas experiencing enduring transmission (where the case rate has remained above the national or regional average for a prolonged period). UKHSA seeks to offer particular support to local authorities experiencing enduring transmission, to recognise the specific characteristics and drivers of higher transmission rates, including that vaccination uptake tends to be lower, and insecure employment can mean rates of testing, tracing and successful self-isolation are lower.

Supporting areas facing enduring transmission will contribute to reducing inequality, as these areas tend to have long-standing patterns of deprivation and health inequalities. Areas experiencing enduring transmission require a sustained approach, with national and regional support to enable and enhance the work of local government. This reflects the fact that enduring transmission is linked to wider socio-economic challenges, rather than being a short-term outbreak.

Local authorities may implement some of these support measures as part of a localised plan developed with the backing of national and regional teams, depending on the epidemiological context, including:

- access to test capacity and communication support for hyper-local targeted testing
- support to plan and maintain public health workforce capacity for COVID-19 response
- capacity to support workplaces and businesses to be COVID-secure post step 4
- national COVID-19 vaccines program support to an area's local planning.

Research Gaps and Strength of Evidence

Now 18 months into the COVID-19 pandemic, it is notable that the evidence base for many commonly recommended strategies is still of very poor quality. The broad society wide NPI's were often implemented simultaneously, in different ways, and were affected by local conditions and are relatively difficult to study because the data are ecologic and epidemiologic. Specific protocols and interventions that can be assessed in a randomized fashion (such as workplace screening methods) are more amendable to higher quality trials but these are few in number. It is noted that widespread vaccination has the highest likelihood of reducing community transmission compared to NPIs, without the negative socioeconomic costs, but that these measures will remain relevant until immunization rates are sufficient to achieve a reasonable degree of population immunity.

Limitations of this review

This interim rapid brief took a pragmatic approach with a targeted search for reviews, meta-analyses, and systematic reviews of the impact of NPIs to control COVID-19 transmission. It is noted that this includes a variety of measures with varied definitions across publications (including but not limited to interventions such as travel restrictions, stay at home orders, business closures, test-trace-isolate, quarantine, and masking orders). Additional targeted and grey literature searches for literature on interventions not covered in the initial resources focused on recent and preprint literature specific to COVID-19 where possible. Evidence based on trials, and analysis of real world outcomes has been preferred over modelling and laboratory based data in this brief. The evidence around this topic is primarily observational and many recommendations are based on experiential public health evidence rather than published evidence.

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