Review Article

Non-Pharmacological Infection Prevention and Control Interventions in COVID-19: What Does the Current Evidence Say?

Abstract

Coronavirus disease-19 (COVID-19), a major global public health emergency has significantly impacted human health and livelihoods. The pandemic continues to spread and treatments and vaccines are at different stages of development. Mass vaccination has been rolled out worldwide. This review article provides a narrative summary of the evidence on various non-pharmacological interventions (NPIs) for COVID-19 containment. The authors reviewed the evidence published by the Norwegian Institute of Public Health map of COVID-19 evidence. Additional literature was identified from PubMed and Google Scholar, preprint sites, and news media. The search terms included "Social distancing measures" and "COVID 19", "Non-pharmacological interventions" and "COVID 19", "COVID-19", "non-pharmacological interventions", "face mask", etc. The strength of the evidence for most studies on NPIs was 'weak to moderate' for restrictive NPIs. Ascertaining the impact of each NPI as a standalone intervention is difficult since NPIs are implemented simultaneously with other measures. Varying testing and reporting strategies across the countries and classification of deaths directly caused by COVID-19 create challenges in assessing the impact of restrictive NPIs on the case numbers and deaths. Evidence on hygiene measures such as face mask is more robust in design providing credible evidence on prevention of COVID-19 infection. Evidence from modeling studies, natural before-after studies, and anecdotal evidence from the strategies adopted by 'role model' countries suggests that continued use of NPIs is the only containment strategy until 'herd immunity' is achieved to reduce the severe disease and mortality.

Keywords: *COVID-19, masks, pandemics, prevention and control*

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Introduction

Coronavirus disease-19 (COVID-19) is a major public health emergency that has infected about 264.6 million people in over 213 countries and territories on December 03, 2021, and caused over 5.2 million deaths.[1] The pandemic continues to spread rapidly across populations prompting governments to undertake drastic measures such as community-wide social distancing, restricted movement of people, and restrictions on economic activities to curb the transmission, and flatten and reduce the epidemic curve. These measures to a certain extent seem to have slowed the epidemic in many countries, however, they have also caused serious economic consequences. These strategies have led to significant reductions in income, increase in unemployment, and disruptions in major industries like transportation, service, and manufacturing.[2]

Considering the competing priorities between saving lives versus saving livelihoods, it is imperative to examine if the public health interventions implemented at an unprecedented scale and at huge economic cost are justified with evidence of their effectiveness. There is a huge evidence gap though there are numerous but conflicting anecdotal evidence as well as scientific papers about the success and failures of the public health interventions available. This makes it imperative to synthesize all available evidence to help policymakers make rational and balanced decisions. At this point in time when there is no effective treatment and the vaccine efficacy is not known and vaccines are not accessible to most individuals, it is important to investigate the impact of NPIs in the COVID-19 containment. The main objective of this review is to summarize the available evidence on the impact of NPIs in the COVID-19 containment.

The Norwegian Institute of Public Health

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in association with other partners has produced a live map of COVID-19 evidence which will help researchers and policymakers navigate the evidence from the studies and analyses of COVID-19 globally.[3] The map was produced in early April 2020 and the last update was on June 28, 2021.

Methods

The authors critically appraised the evidence listed in the live map of COVID-19 evidence and primary studies and systematic reviews identified by our search of the PubMed and Google Scholar database using the terms "Social distancing measures" and "COVID 19", "Non-pharmacological interventions" and "COVID 19", "COVID-19", "non-pharmacological interventions", "face mask", etc. The abstracts of different articles were read by all the authors followed by a full-text review of relevant articles. The search included journal articles published between January 1, 2020 and October 1, 2020. Preprint sites were also searched. The evidence categorization was performed using Grading of Recommendations, Assessment, Development and Evaluations 'GRADE certainty ratings' as very low, low, moderate, and good.[4] The newspaper and other reports were included in the section on underreporting of COVID-19 cases and deaths which can affect the evidence regarding the efficacy of the NPIs and where there is a lack of traditional scientific studies. We divide the NPIs into restrictive and hygiene. The restrictive ones are described first and include restrictions on schools and kindergartens, businesses, events and gatherings, movements of people including international travel, work from home, quarantine, and self-isolation. The hygiene ones are the use of face masks and hand hygiene.

Restrictive NPIs

Restrictions on schools and kindergartens

Many countries implemented this measure despite the lack of evidence from the current COVID-19 pandemic. Evidence was studies done using data from influenza, Middle East respiratory syndrome (MERS), and severe acute respiratory syndrome (SARS) outbreaks or modeling studies based on data from these outbreaks evidence suggests that school closures may be effective in the prevention of influenza transmission since children have higher attack rates. However, for COVID-19, children have similar attack rates as adults. Hence, it is not known if school closures would have any impact on slowing the transmission as most COVID-19-infected children suffer either mild symptoms or remain asymptomatic. School closures have often been among the package of wider social distancing (SD) measures and it may be difficult to judge its impact. Nevertheless, a possibility of a potential transmission to family members exists if the children contract infection in the school. Current evidence is inconclusive if school closure will slow the transmission while the consequences of social disruption seem to be much higher. It has been recommended that less disruptive SD interventions be implemented considering the high economic costs and potential harms to the education system from school closures.[5]

A modeling study from Singapore showed a substantial reduction in the number of cases[6] and an observational study from Hong Kong[7] based on data from COVID-19, influenza illness, and hospitalization reported a 33% reduction in pediatric admissions. However, in both the studies, school closures were a part of the packaged SD interventions but not a standalone intervention. Mild COVID-19 disease and asymptomatic infection among children,[8] and lack of evidence of the impact of school closure alone on COVID-19 transmission limits its utility as a measure to contain the COVID-19 pandemic.

Restrictions on businesses

There is scarce evidence on the impact of restrictions or closure of businesses, which is also a component of a broader community-wide SD measures. It has been recommended that for measures such as business closures to be successful, timely, i.e., early implementation is needed to delay the epidemic peak and maintain an appropriate duration to contain the epidemic.[9] Available evidence from several Asian countries using news reports and publicly available data on COVID-19 disease indicators help us to conclude that information is sparse, data inconclusive, and there is possible underreporting. An econometric analysis of the secondary data in Italy assessed the relationship of air quality with COVID-19 mortality and reported that the presence of micro (artisan) firms and businesses correlated positively with contagion and mortality.[10] Assessing the impact of business restriction/closure on transmission may not be amenable to experimental design, however, an empirical study from Asian countries suggests crowding inside may perhaps be avoided to slow the transmission. Such interventions need confirmation at least from interrupted time-series studies or difference-in-difference analyses.

Restrictions on events and gatherings

Like for other measures, modeling studies have been used to provide evidence for the usefulness of this SD measure. A study mentions that quarantine combined with school closures, travel restrictions, and SD produced a greater effect on the new cases, transmission, and death than individual methods alone.[11] A non-standard rapid Cochrane review reported that there was a reduction of new cases and deaths albeit with low certainty of evidence. However, these results were based on the modeling studies that simulated various scenarios of quarantine combined with other similar measures. The results of this review are limited by low certainty and simulations based on SARS and MERS outbreaks which have different disease transmission dynamics. It is important to note that the community mitigation strategies including bans of

gatherings should be better aligned with the severity and geographic spread of the outbreak as such measures could substantially impact normal life.[12]

Restrictions on movements of people

There are only two systematic reviews on this topic. These have been mentioned previously.[8,10] A study in China examined the effects of a city-wide lockdown to halt the spread of the virus within a city.[13] The authors mention that the lessons learned within China can be applied to the other cities and countries. A recent paper does, however, raise concern about the crippled community governance in China and the suppression of scientific and professional communities which may have crippled the early warning systems for COVID-19 in the country and may have contributed to its early rapid spread.[14] Another study from China examined the correlation between the domestic air traffic and the number of and growth of confirmed COVID-19 cases.[15] The authors concluded that there was a significant increase in the doubling time of cases after the lockdown but the correlation between the domestic air traffic and COVID-19 spread became weaker.

Restrictions on international air travel

A study explored the impact of reduced travel from China on the exportation dynamics of COVID-19 to Japan. The authors concluded that the probability of a major epidemic reduced between 7 and 20% in Japan and the time delay to a major epidemic increased by 2 days.[16] Another study concluded that around 70.5% of the 779 postulated cases to be exported were averted by lockdowns and travel bans. The travel restrictions decreased the daily exportation rate by an average of 81.3%.[17] The association between the air traffic and the risk of spread of COVID-19 was investigated. There was a significant correlation between the international air traffic and COVID-19 cases.[18]

Monte Carlo simulation models showed that a ban on international air travel could avert up to 90% of imported cases in the receiving countries. Crowded airports and enclosed pressurized cabin of an airplane, both are possibly conducive for airborne transmission. Neither international health agencies nor governments consider international travel bans and/or border restrictions barring a few as a possible control measure.[19]

Work from home

Working from home is intended to reduce human-to-human contact at the workplace and while in transit to work. It is of the utmost importance to inform the public about the benefits of work from home and encourage a positive behavioral change among the population to achieve the desired outcomes.

Interestingly, the public perceptions about the perceived severity of infection vary by geographic regions, as shown in a study that the perception of the risk of being infected was higher in Asian countries compared to North American or European countries.[20] According to the health belief model 'risk perception' has an important role in the health behavior of people. Higher levels of risk perception improve the compliance to public health measures for the prevention of COVID-19 such as the adoption of preventive practices.

Quarantine and self-isolation

Among the different measures, quarantine has been extensively studied. The effectiveness of the community quarantine strategy was studied in Anhui province, China.[21] It significantly slowed the spread of the disease. The authors also mention that the implementation and maintenance of the strategy is costly and requires the support of the entire population. A parsimonious model was introduced that took into consideration both the quarantine of symptomatic-infected individuals and population-wide isolation strategies.[22] The authors attribute the sub-exponential increase in cases in China to the containment policies instituted.

The first 100 cases in Singapore were analyzed to determine the effectiveness of the containment and surveillance measures.[23] The authors concluded that rapid identification and isolation of cases, quarantine of close contacts, and active monitoring of other contacts have been effective in suppressing the expansion of the outbreak. Adherence to quarantine varies widely. Public health officials should provide a timely, clear rationale for quarantine; emphasize social norms to encourage it; emphasize the perceived benefit that engaging in quarantine will have on public health; and ensure that enough supplies are provided.[24] A study from Israel found that compensating people for lost wages significantly improved quarantine compliance rates.[25] Providing a clear rationale for quarantine, providing adequate supplies, and not quarantining longer than required have also been mentioned in another study.[26] Precision 'physical distancing' is distancing tailored and optimized to specific physical, social, cultural, political, and economic contexts and specific groups and settings. It has the advantages of being low cost, adaptable to diverse sociocultural and economic settings, and more easily monitored and potentially enforced than less precise measures.[27]

An observation of COVID-19 patients in a respiratory surveillance ward of a Singaporean hospital showed that none of the other hospitalized patients and their health workers caring for them were infected even after 2 weeks of follow-up. Notably, all these patients were following SD very strictly despite sharing the ward and other facilities and had adhered to wearing of the masks.[28] A study in the city of Belo Horizonte, Minas Gerais State, Brazil used a classic mathematical model of SEIR epidemics (susceptible-exposed-infected [symptomatic and asymptomatic]-removed) wherein vertical SD policy, i.e., for older adults and horizontal distancing

policy for all age groups were compared with no intervention as control in a mathematical model. In this study, horizontal but not the vertical distancing slowed the epidemic suggesting SD should be applied community-wide to entire populations.[29] In an event-study design from the USA, the impact of the closure of public gathering places and stay-in-shelter-orders was compared with the growth rates during the days after these orders were passed using county-wise official data on COVID-19. The study found that there was an incremental decrease in the growth (R0) suggesting that without these interventions there would be up to a 35 times greater spread of COVID-19.[30]

Hygiene NPIs

Use of face masks

A rapid systematic review examined the efficacy of face masks and respirators against the respiratory infections among the community, health workers, and the public. In the community, masks were more effective than hand hygiene alone and both measures together were more protective against the influenza infections.[31] Among the healthcare workers, respirators were protective only if worn continuously during a shift but not if worn intermittently. When masks are used by sick people, all contacts were protected. Thus far, the evidence on the use of face masks was most robust as the primary studies included were all randomized controlled trials and had a good number of individuals included in them. The evidence on the mask can be most readily applied to the prevention of COVID-19 as it shares the transmission dynamics with the influenza virus. A study on a single participant using filtered eye masks recommended by the Centers for Disease Control (CDC) to prevent the transmission of COVID-19 via inoculation of the virus on the conjunctiva showed that non-hermetically sealed eyewear may potentially prevent the viral droplet inoculation on the conjunctiva.[32] It is common practice to see people wearing face masks as well as face shields. Experts opine that wearing a mask even in public places by everyone has the potential to reduce the transmission from asymptomatic as well infectious individuals.[33] The evidence of face mask is also supported by a laboratory experiment that studied the efficiency of various materials for these masks. N95 masks, medical masks, and homemade masks made of four-layer kitchen paper and one-layer cloth could block 99.98%, 97.14%, and 95.15% of the virus in the aerosols.[34] Another rapid review of the randomized controlled trials in community settings reported that medical masks and cloth masks were much less effective.[35]

A study in Hong Kong examined confirmed COVID-19 cases reported from mask-off and mask-on settings and reported that compliance of the public with mask-wearing recommendations was over 96%. They also noted a significantly higher COVID-19 cluster in recreational 'mask-off' settings suggesting that masks may potentially prevent the transmission.[36] Model simulations in the US states of New York and Washington showed that immediate near-universal adoption of moderately effective masks would prevent 17–45% of projected deaths over the next 2 months and decrease the peak daily death rate by 34–58% even in the absence of other interventions. The use of even very weak masks is still likely to be effective.[37]

Hand hygiene

Hand hygiene and other personal protective measures were studied in Japan. The median daily hand hygiene events were 5 per day which the authors concluded were insufficient considering the meals eaten and the frequency of using the restroom.[38] Among the respondents, 58.5% always followed proper hand hygiene while 25.2% followed it sometimes. In some low-income communities, soap and alcohol-based sanitizers may be unavailable, and the authors examined the efficacy of ash for hand hygiene. They concluded that it is uncertain whether handwashing with ash stops or reduces the spread of the infections.[39]

Hand hygiene by washing hands or using hand sanitizers and sanitization of fomites and surfaces has been highly recommended during the current pandemic. However, there is very weak or lack of evidence on the effectiveness of hand hygiene since the limited studies included had used unreliable methods, studied different populations groups, and none of the studies were examined.

Underreporting of COVID-19 cases and implications for control

The control of the COVID-19 pandemic depends on accurate data as it is a new disease and data from other diseases may not be suitable. We could not come across journal articles on this topic, but it has received a wide coverage in the media. The following description is based on the newspaper and other media reports which may not have been peer-reviewed and should be interpreted with caution. Underreporting of cases has been reported in many countries including the US,[40] European countries,[40] Philippines,[41] India,[42] among other countries. Many of the early interventions which have been reported were carried out in China, and then, adopted by other countries. Recently, there have been concerns about underreporting of cases in China and the accuracy of the data provided. China may have underreported thousands of deaths according to a recent report.[43] The authors of a recent study indicate that countries like France, Italy, the United States, Iran and Spain have extremely high numbers of undetected and underreported cases.[44] Reports of underreporting may need confirmation but can impact the effectiveness of different NPIs described in this manuscript.

A summary of the findings about different NPIs based on the available literature is tabulated in Table 1. A few studies not described in the text have also been included. The strength of evidence available for many of these studies has also been mentioned.

Table 1: Reviews and other articles examining non-pharmacological interventions in COVID-19

Description of intervention	Participants (may not be applicable for all studies)	Design	Comparison	Outcomes	Limitation	Strength of evidence*	Study citation
School closure (restrictive)	School children	Systematic review search of three databases (PUBMED, WHO Global research database, preprint server medRxiv) and manual search	Data from SARS outbreak were compared with school closure and normal schooling times	School closures alone can prevent only 2-4% of deaths	Authors did not assess the quality of studies prior to the inclusion due to the urgency of evidence	Very low	Reference 5
School closures, extended workplace closures, and a reduction in mixing in the general community (restrictive)	General public in Wuhan, China	Age-structured susceptible-exposed-infected-removed (SEIR) model	Different degrees of social distancing during various stages of lockdown were compared	The benefits of school closure offer healthcare systems time to expand and respond to the pandemic	Modeled estimates did not account for individual susceptibility and for the likelihood of familial clustering of cases when public places remain closed	Moderate	Reference 45
School closure (restrictive)	Healthcare workers with children involved in childcare in case of school closure	Analysis of data from the current US population survey	Pressure on the healthcare supply due to the workers being involved in childcare in case of school closure vs no closure of schools	Unclear whether potential COVID-19 prevention benefits justify the potential absence of healthcare workers due to their obligations	-	Moderate	Reference 46
School closure (restrictive)	School-going children in low-middle income countries	Authors' viewpoint	Social, educational, and nutritional effect on children	School closure is associated with a significant negative impact on nutrition and learning opportunities for school-going children		Very low	Reference 47
School closure (restrictive)	US residents	Population-based observational study	Difference in COVID-19 morbidity and mortality among the US states which closed schools vs the ones which did not	Temporarily, the school closures were associated with reduced morbidity and mortality	The reduction in morbidity and mortality may not be solely attributable to school closure as there were also other non-pharmacological measures implemented	Moderate	Reference 48
Delaying the opening of schools/ school closure (restrictive)	School-going children in South Korea	Modeling study	Opening the school as per the schedule vs delaying the opening	Delayed school reopening reduced the total number of cases	The findings are based on multiple assumptions	Moderate	Reference 49

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Table 1: Contd...

Description of intervention	Participants (may not be applicable for all studies)	Design	Comparison	Outcomes	Limitation	Strength of evidence*	Study citation
Reopening of schools (removing restrictions)	School-going children in Ireland	Case study involving six cases	Effect of school reopening on spread of COVID- 19	Schools have only limited role in virus spread provided adequate measures are taken	Limited number of individuals. School children aged less than 10 years were not included	Very low	Reference 50
Strong social distancing measures (restrictive)	United States population	Event study regression with multiple policies	Estimation of the relationship between social distancing policies and the exponential growth rate of confirmed COVID-19 cases	Social distancing measures reduced the daily growth rate by an increased % depending on the duration reaching 9.1% after 16-20 days	Asymptomatic carriers may not be included in the estimate	Low	Reference 30
Restriction and cancellation of mass gatherings (restrictive)	Not specific	Review of reports mentioning mass gatherings in selected countries	Disease outbreak of previous infectious conditions like flu in the past	Though the effect of restriction and mass gatherings during the pandemic is poorly established, previous data shows multiple events increase the risk of respiratory infections	The data included in this review were retrospective questionnaire-based studies involving little or no laboratory confirmation of infections	Low	Reference 51
Mass gatherings (restrictive)	-	Opinion based on review of published studies highlighting significance of cancellation of mass gatherings in the past. A case scenario of the Umrah pilgrimage provided	-	Mass gatherings generally promote the expansion of disease outbreaks	Limited data without any specific interventions	Very low	Reference 52
Mass gathering event in Malaysia (restrictive)	Participants of a mass gathering religious event in Malaysia (February 27, 2020 to March 1, 2020)	Opinion	-	This event catalyzed the spread of COVID-19 in Malaysia and across Southeast Asia	The evidence is based on the screening of the participants of the event	Moderate	Reference 53
Benefit of thermal scanning in mass gatherings	Participants of mass gathering events	Opinion	-	Thermal scanning cannot completely identify patients since it takes 2-10 days for the symptoms to occur	-	High	Reference 54

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Table 1: Contd...

Description of intervention	Participants (may not be applicable for all studies)	Design	Comparison	Outcomes	Limitation	Strength of evidence*	Study citation
Lockdown and its impact on COVID-19 (restrictive)	Confirmed cases	Passenger data from the Civil Aviation Administration of China collected and compared with COVID-positive cases. Modeling study was conducted	Number of COVID-positive individuals in Wuhan before and after lockdown	A more stringent confinement of people in high-risk areas seems to have the potential to slow down the spread	The model parameters are based on the early COVID-19 outbreak, SARS, and MERS epidemiology	High	Reference 15
Travel restriction (restrictive)	Travelers (international and domestic)	Modeling study based on the epidemiological data from China	Case importation and transmissibility of the virus before and after travel restriction	Travel restriction reduced the epidemic progression in Mainland China by 3-5 days and had more marked effects on international spread of the virus	The model parameters based on the early COVID-19 outbreak, SARS, and MERS epidemiology	Low	Reference 55
International travel restriction and border control measures (restrictive)	International travelers traveling to and from Mainland China	Estimate of the impact of these interventions on global spread of the infection	Importation of active cases into unaffected areas	Border control measures, such as airport screening and travel restrictions, slowed the rate of exportation from Mainland China to other countries, but were insufficient to contain the global spread	-	Moderate	Reference 17
International travel restriction (restrictive)	International travelers traveling to and from China	Statistical modeling	Normal number of international travelers with reduced numbers because of travel restriction	Travel restriction prevents exporting cases, delays development of the epidemic, and reduces incidence	The study relied on a volume of cases diagnosed outside China and did not directly examine human migration data	Moderate	Reference 16
Social distancing (restrictive)	Passengers and staff members on a cruise ship	Survey and interviews with crew members	-	Spread among persons staying in the same deck and staff members serving the deck suggesting spread through contact and droplet	-	High	Reference 56

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Table 1: Contd...

Description of intervention	Participants (may not be applicable for all studies)	Design	Comparison	Outcomes	Limitation	Strength of evidence*	Study citation
Quarantine (restrictive)	Viewpoint	-	-	In general, public tries to avoid voluntary quarantine. Loss of individual freedom must be carefully balanced with the public interest	-	-	Reference 57
Effect of quarantine alone and in combination with other non-pharmacological interventions (restrictive)	-	Systematic review	Number of cases (confirmed or suspected)	Quarantine reduces the number of active cases. But when combined with other methods had greater effects	Of the 29 studies included in the review, 15 were based on SARS and MERS and cannot be generalized to COVID-19	Moderate	Reference 11
Face mask use during COVID-19 (hygiene)	General public in New York and Washington states	Compartment model involving public who are asymptomatic	-	Use of face masks by the public is potentially of high value in curtailing community transmission	The model does not consider the high percentage of people who may not comply with face mask use and the efficacy of various types of masks	Moderate	Reference 37
Face mask use against COVID-19 (hygiene)	General public	Evidence review in which literature was gathered by a group of multidisciplinary researchers		With high compliance face mask use can be the most effective strategy in preventing the virus spread	-	-	Reference 58
Face mask use in COVID-19 (hygiene)	General public	Personal view based on available evidence	-	Face masks are simple, cheap, and potentially effective and could have a substantial impact on the transmission with a relatively small impact on social and economic life	-	-	Reference 59
Use of N95 mask, goggles, face shield, gloves among health workers (hygiene)	700 individuals, consisting of physicians and nurses working in tertiary hospitals in Hubei, China	Self-administered online questionnaires	-	97% prevalence rate of skin damage caused by enhanced infection-prevention measures. Nasal bridge was affected in 83.1% of the cases	In some health workers, there could be multiple causative factors for skin problems	Moderate	Reference 60

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Table 1: Contd...

Description of intervention	Participants (may not be applicable for all studies)	Design	Comparison	Outcomes	Limitation	Strength of evidence*	Study citation
Use of topical aerosol agents preoperatively to prevent COVID-19 infection (hygiene)	-	Systematic review including published articles from PubMed/ Medline	Reduction in active viral case spread during upper nasopharyngeal mucosal surgery	Povidone-iodine solutions ranging from 0.23 to 7% found to be effective in reducing the viral count	The findings used an assumption based on the previous viral infections	Very low	Reference 61

*Very low=The true effect is probably markedly different from the estimated effect; Low=The true effect might be markedly different from the estimated effect; Moderate=The authors believe that the true effect is probably close to the estimated effect; High=The authors have a lot of confidence that the true effect is similar to the estimated effect

Impact of NPIs in countries where they were strictly implemented

In the light of a lack of robust evidence on the impact of NPIs on case rates and mortality rates, we provide the stringency index, cases, and deaths per million for selected countries in Table 2.

At the beginning of the epidemic, a few countries such as the US and UK were circumspect on implementing NPIs. On the other hand, Australia and New Zealand were very quick to implement NPIs from the start. In Australia, a strict lockdown and proactive testing and tracing were implemented to contain the virus spread, and the country recorded zero cases per day at 5 months of the pandemic.[62] Similarly, in New Zealand, quarantine following travel, closing of borders, lockdown, case isolation and contact tracing were implemented during March 16–19, 2020. These initiatives were considered responsible for the low all-cause mortality in New Zealand during the COVID-19 times.[63]

Among the European countries, Sweden had fewer restrictions. In Sweden, a death rate of 787 per million population has been reported which was around 4.5 times higher than its neighboring Nordic countries.[64]

Among the Asian countries, Japan, Singapore, Taiwan, and South Korea were very proactive in fighting the pandemic. They have good public health systems, previous experience of SARS, and effective contact tracing. Their infection and mortality rates are low. In Japan, the initial spread of the virus was high, and eventually, the government initiated many NPIs and successfully contained the infection spread. In Singapore, the death rate due to COVID-19 is among the lowest in the world. One of the main reasons for the low mortality rate is attributed to mandatory face mask use.[65] In Taiwan, the success story was attributed to border control, mask distribution, quarantine, contact tracing, etc. In South Korea, self-isolation and contact tracing were the main reasons for the success in containing the virus.[66]

Conclusion

A weak-to-moderate evidence from modeling and quasi-experimental and anecdotal evidence from exemplar countries indicates that early and strict implementation of restrictive NPIs at a wider population level could keep the case numbers and mortality rates low. Hygiene measures such as a face mask appear more effective to prevent transmission of infection at the individual level. Socio-economic negative impacts of restrictive NPIs at the community level in the long run are unsustainable and mass vaccination to reach herd immunity offers the only long-term intervention to keep the infection and mortality rates low. Face mask wearing should be continued for personal protection from COVID-19 even after the vaccination.

Table 2: Non-pharmacological interventions and mortality associated with COVID-19

Countries	Maximum stringency index during March 2020 to March 2021	Stringency index on March 27, 2021	Cases of COVID per million	Deaths due to COVID per million
Asia				
Japan	50.93	42.59	3720.54	71.97
South Korea	82.41	58.33	1964.44	33.24
Singapore	76.85	50.93	10432.51	5.19
India	100	66.20	8640.23	116.17
Taiwan	31.48	25.00	42.85	0.42
Europe				
UK	87.96	78.7	64088.74	1872.38
Sweden	69.44	65.74	73517.23	1263.15
Germany	85.19	75	33530.02	920.19
France	87.96	68.52	69749.71	1451.53
North America				
Canada	75.46	71.76	25405.37	602.10
USA	75.46	66.2	93009.32	1689.77
Australia	81.94	44.91	1131.10	35.12
New Zealand	96.30	22.22	477.30	5.00

NB: The stringency index varied across countries over a one-year period. The maximum value of the stringency index during the period and the value on March 27, 2021 are mentioned. The number of COVID-19 cases and deaths as mentioned according to the Worldometer database and the population of the country in 2021 based on the United Nations data

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Conflicts of interest

The authors have no conflict of interest to declare.

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