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Effectiveness of different types and levels of social distancing measures: a scoping review of global evidence from early to middle stage of COVID-19 pandemic

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Abstract

Objective: Social distancing is the critical measure in the control of the COVID-19 pandemic before herd immunity can be achieved through effective vaccination of global populations. This scoping review aims to synthesize research findings on the effectiveness of different types and levels of social distancing measures from early to middle stage of COVID-19 pandemic.

Design: Scoping review.

Data Sources: Seven electronic databases were searched for eligible research studies on social distancing for COVID-19 published from beginning of the pandemic till October 2020.

Study selection and data extraction: The measures covered social distancing between individuals, school closure, workplace/ business closures, public transport restriction, "partial" lockdown and full lockdown. Effectiveness indicators included five aspects: 1) infectivity, 2) incidence, 3) mortality rate, 4) effect time, and 5) attendance.

Results: After screening 1288 abstracts and 8 additional articles from other sources, 34 studies were included for synthesis of findings. The review found that the outcomes of social distancing measures were mainly indicated by changes in Rt, incidence and mortality, along with indirect indicators such as daily contact frequency and travel distance. There was empirical evidence for the effect of social distancing at individual level. The evidence was also adequate for partial or full lockdown at community level. However, at the level of social settings, the evidence was inconsistent for school closure and public transport restriction as a single type of intervention. The evidence was also very limited for workplace/business closures.

Conclusions: In the community setting, there was stronger evidence on the combined effect of different social distancing interventions than for a single one. As fatigue of preventive behaviors is on the top of the public health agenda, future studies should analyze risk in specific settings such as eateries and entertainment to implement and evaluate measures which are proportionate to the risk.

Keywords: COVID-19, effectiveness, incidence, scoping review, social distancing

Strengths and limitations of this study

- Frist scoping review to synthesize findings on the effectiveness of social distancing measures for COVID-19 at individual, social settings and national levels in a variety of outcome parameters.
- This review shows the amount of evidence for different types and levels of social distancing measures.
- Findings in varied outcome parameters could not be compared directly.
- Non-English literature was excluded from this review.

Introduction

Social distancing is the most important measure to control the outbreak of COVID-19 worldwide before herd immunity can be achieved through effective vaccination (1). Social distancing, also known as physical distancing, is based on the premise that the rate of transmission of infectious diseases will decrease if people in communities stay at home from work or school, avoid large gatherings and refrain from having physical contact with one another. World Health Organization (WHO) guidelines describe social distancing measures at the individual level, e.g. keeping at least one meter from each other; at the community level generally, e.g. stay-at-home recommendation/ordinances; or in specific socio-economic settings e.g. measures for workplace, schools, eateries, entertainment and parties (2, 3). At the national or regional levels, lockdown or community quarantine may be imposed as an extreme form of social distancing (4, 5), where it can be total or "partial" when key socio-economic activities are restricted (6).

Despite the fact that social distancing measures have become a crucial strategy globally to mitigate COVID-19 pandemic, the evidence for their effectiveness is just slowly accruing. Earlier studies applied mathematical modelling to predict effectiveness of social distancing measures (7-10). Recent studies evaluated the outcomes retrospectively using empirical data and reported the outcomes in specific parameters. A study analyzed data from 149 countries suggested that implementation of any social distancing intervention was associated with an overall reduction in COVID-19 incidence of 13% (IRR 0.87, 95% CI: 0.85 - 0.89) (11). It concluded that data from 11 countries indicated similar overall effectiveness (pooled IRR 0.85, 0.81 to 0.89) when school closures, workplace closures, and restrictions on mass gatherings were in place (11). The European Centre for Disease Prevention and Control (ECDC) also estimated the effectiveness of different types of social distancing in Europe. While most were based on prediction modelling, some retrospective analysis showed that lockdown reduced R_t from around 2.7 to around 0.6 in the UK (12). Given the different types, variations and

combinations of social distancing measures were implemented at different levels in different jurisdictions and pandemic contexts, it is important to study what parameters and methods were used and what outcomes were measured in various research studies. This is critical in a protracted pandemic after continuing restrictions to self-determinants and socio-economic life, which have led to fatigue in preventive behaviors. In this context, targeted measures which have been evaluated proportionate to the risks should motivate continuing preventive behaviors.

The aim of this study was to synthesize research findings on the effectiveness of different types and levels of social distancing measures from early to middle stage of COVID-19 pandemic. The study was conducted as a scoping review to include a broad range of outcome parameters and study designs. This enables a better understanding the effectiveness of the spectrum of social distancing measures in controlling COVID-19 outbreak.

Methods

The scoping review method was applied to include a range of parameters relating to effectiveness of social distancing measures during COVID-19 pandemic. In contrast to a systematic review which answers a specific and narrow question, a scoping review aims to explore a set of emerging and diverse themes to synthesize the current evidence, clarify conceptual parameters and identify gaps for further research (13-15).

Eligibility criteria

Inclusion criteria for this review were studies that described: 1) effectiveness or outcomes of social distancing measures targeting the general public; 2) social distancing measures including those between individuals; targeted measures on including closures of schools, workplaces, restaurants and

bars, and other social settings; stay-at-home recommendation or ordinances, community quarantine and lockdown; and 3) quantitative research, secondary data analysis, modelling studies based on empirical data, and review articles.

Exclusion criteria were: 1) qualitative studies, commentaries, mini-reviews without search strategies, editorials, conference presentations, dissertations, and book chapters); 2) non-English articles; 3) studies in healthcare settings, such as those on healthcare workers, hospital patients and elderly nursing homes; 4) studies on the impact of social distancing measures on non-COVID-19 diseases and psychosocial health of the public; and 5) hypothetical models *not* based on empirical data.

Search strategies and study selection

Seven electronic databases including AMED, Embase, Global Health, MEDLINE, Ovid Nursing Database, APA PsycInfo, Social Work Abstracts were searched by an experienced team member in scoping and systematic reviews. The search period was from the inception of the databases to 30 September 2020. To enhance sensitivity, syntax of *"COVID*".m_titl. AND social distan*.ab* and *"COVID*".m_titl. AND physical distan*.ab* were used as search strategies to cover both terms of social physical and physical distancing. Furthermore, backward searches from the reference lists of the articles to locate additional articles and reports. The search and selection process followed the Joanna Briggs Institute Methods Manual for scoping reviews, and the reporting was guided by PRISMA Extension for Scoping Reviews (PRISMA-ScR)(16). Two reviewers independently screened the titles and abstracts to assess their eligibility. Full texts of potential citations were retrieved for detailed examination. Selection discrepancies were settled through discussions between these two reviewers. Any outstanding disagreements were resolved by consulting the third member. We did not conduct risk of bias assessment, which is consistent with recommendations from the Joanna Briggs Institute Scoping Review Methods Manual and PRISMA-ScR (16). Different from a systematic review, a

scoping review aims to provide an overview of the existing evidence comprehensively, regardless of risk of bias of included studies (16).

Data extraction and synthesis

For each study included, texts under the headings of 'results' or 'findings' were extracted and analyzed by two reviewers. The analysis was performed by one reviewer and verified by a second reviewer. The two reviewers reached consensus upon the outcomes reported and the classification of their types of social distancing and effectiveness indicators.

Patient and public involvement statement

It was not appropriate or possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research.

Results

Study selection and characteristics

We screened 1288 abstracts from our electronic search on the databases with 2 additional research reports being identified from governmental websites. Of the 95 full texts retrieved for further assessment, 29 articles fulfilled our eligibility criteria. In addition, 6 relevant studies were identified from the reference lists of the articles through backward searches. Hence, in total, 34 studies were included in this review. Figure 1 presents results of the literature search and classification flow, and Table 1 provides detailed characteristics of the selected articles.

(Insert Figure 1 and Table 1 here)

There were 31 research studies and 3 reviews. Twelve studies reported data from North America, another 12 from Asia, 9 from Europe, 3 from South America and 1 from Australia. There were also 3 global studies which reported data from over 50 countries in multiple regions. According to the classification by World Bank (15), 59.1% of the studies were from high-income countries/regions, 34.1% from middle-income and 6.8% from low-income countries/regions.

Table 2 summarizes the key findings based on the effectiveness indicators including the following aspects: 1) Infectivity: R_t, effective reduction number; 2) Incidence: infection incidence, ratio of incidence rate, attack rate, or bed occupancy rate; 3) Mortality or fatality rate; 4) Effect time: action and effect duration, time of reaching peak; 5) Attendance percentage of location, daily vehicles miles, daily contact frequency, mobility of leaving home, or travel distance. A description of each type of intervention is also given. A tick "✓" is put if no detailed elaboration was provided in the reviewed articles.

(Insert Table 2 here)

Social distancing at individual level

Social distancing measure was usually achieved by the prohibition of mass gathering in public areas and/ or maintaining certain physical distance between people. Most studies reported a positive relationship between the transmission risk and certain level of social distancing. A meta-analysis including seven studies on COVID-19 concluded that physical distancing of 1 meter or more was effective to reduce the transmission risk by 5 times and the protective impact was double for every extra meter (17). Similarly, based on the chronological data on interventions in 41 countries between January and May 2020, Brauner et al. (18) estimated that Rt reduced by 36%, 28% and 12% when gatherings were limited to 10, 100 and 1,000 people respectively. Furthermore, studies also found how

mobility changed according to different social distancing measures. A study by Weill et al. (19) in the U.S. found that median distance traveled, retail and recreation locations visited by a mobile device per day showed a sharp decrease in March 2020 after the implementation of social distancing measures in the country, while percentage of completely staying at home doubled. Another US study by Clipman et al. (20), in Maryland, found that history of COVID-19 infection was significantly less likely among the public who always practised social distancing (aOR for indoor social distancing, 0.32 [95% CI, .10–.99]; aOR for outdoor social distancing, 0.10 [95% CI, .03–.33]), giving some hints on the implications of mobility during the pandemic. However, social distancing in different settings may have different impacts. The UK Scientific Advisory Group for Emergencies (SAGE) meeting report (21) suggested that stopping contact from different households would provide moderate impact by reducing R_t of 0.1-0.2 but the impact of physical distancing on outdoor gathering was minimal (R_t reduction <0.05) since good ventilation was usually observed.

Social distancing at level of community settings

School closure

School closure may have benefits during the pandemic, but the effectiveness was mixed when considering levels of closures and the unexpected link between school closure and school opening. Rivkees's (22) study in Florida of the U.S. found that closing schools resulted in a 40-55% reduction in average distance traveled compared with pre-outbreak levels. Moreover, Auger et al. (23) found that the primary and secondary school closure in the U.S. between March and May 2020 was associated with decreased COVID-19 incidence (adjusted relative change per week, −62%) and mortality (−58%). On the other hand, the SAGE report (21) suggested that closing secondary schools and further education could have more impact, even though a moderate R_t drop of 0.1 – 0.5 was associated with mass school closure, as mature students worked in daytime and linked up infection pathways between

workplace and households. It was also proposed that states closing schools earlier, when cumulative incidence of COVID-19 was low, had the largest relative reduction in incidence and mortality, although there might be confounding effects from other interventions (24). Contrary to expected impacts of school closures, observational data in ECDC review suggested that re-opening schools had not been associated with significant increases of community transmission (12).

Workplace measures

Workplace measures include work-from-home arrangement, measures in working environment and the closure of businesses. The SAGE report (21) suggested a moderate impact of work-from-home measure, with a reduction of R_t between 0.2 and 0.4. Brauner et al. (18) estimated that a 29% R_t reduction was likely to follow with closing most of non-essential businesses while closing high risk businesses, e.g. bars and restaurants would be associated with a Rt decline of 20%.

Public transport restriction

Public transport restriction refers to suspension/ limitation of intra-city or intercity public transportation. The SAGE report (21) suggested a low to moderate impact following the 5-mile travel restriction, especially when local outbreak was widespread. It might be because public transport crowding was low and mandated face-mask policy was already implemented. However, Islam's study (11) showed no difference in reduction with or without the suspension of public transportation. On the other hand, ECDC review showed contradictory results, with a modelling study indicating a strong association with reduction of Rt while other studies did not show any impact unless introduced with other NPIs such as social distancing and behavioral changes (12). Therefore, it is difficult to relate observed changes in transmission dynamics to this single measure of public transport restriction.

Social distancing at national/regional level

Combination of interventions - "partial" lockdown

While the studies mentioned above focused on the effect of single type of intervention, many studies showed the effect of a combination of interventions, which could be regarded as a "partial" lockdown. A study by Siedner et al. (24) in the U.S. found that the mean daily COVID-19 case growth rate fell by 0.9% per day, starting 4 days after implementation of the first statewide social distancing measures including cancellation of public events, travel restriction, school and workplace closures. A drop of 2% in daily COVID-19-attributed mortality growth rate was also observed after 7 days the measures were implemented. Similarly, a study by Wan et al. (25) in Mainland China excluding Hubei (province of Wuhan) found that R_t has dropped sharply from 3.34 on 20 January 2020 to 0.89 on 31 January 2020 after implementing integrated control strategies. In Du's study (26) of 58 cities in China, also with a remarkable Rt drop, at 54.3%, demonstrating the effectiveness after the implementation of multiple types of interventions.

Full lockdown

Indeed, a full lockdown can be viewed as a combination of all measures. Islam et al. (11) reported a combination of 4 measures, including restrictions on mass gatherings, school closures, workplace closures, and lockdowns in 32 countries, were associated with decreasing incidence of COVID-19 (pooled incident rate ratio, IRR 0.87, 0.84 to 0.91). Similar declining incidence was also observed when public transport closure was added (pooled IRR 0.85, 0.82 to 0.88; n=72 countries). Other than incidence drop, bed occupancy could be also benefited from lockdown measures. In Lino's study (5), before the lockdown, the bed occupancy rates for referred COVID-19 cases in a tertiary hospital in Fortaleza of Brazil were over 100% in the beginning of May and reached nearly 140% after 10 days. The rates decreased to below 100% and 85% at 14 and 23 days respectively after the lockdown.

More evidence showed the effect of lockdown by various indicators. Zhang et al. (27) found that an average daily number of contacts per survey participant significantly dropped from 14.6 to 2 and 18.8 to 2.3 in Wuhan and Shanghai respectively during the lockdown period, consistent with the respective trends of mobility data declining at 86.9% and 74.5%. Pan et al. (28) analyzed data from Wuhan and found that the R_t gradually reduced from larger than 3 in January 2020 to less than 1 in February 2020 and fell further to less than 0.3 in March 2020 after the city lockdown. Similarly, a brief report of Rivkees et al. (22) showed that the stay-at- home order in Florida of the U.S., after the first month of implementation, resulted in a 74% to 82% reduction in person-to-person encounters, 55% in visits to non-essential venues and 45% in overall distance traveled. After two months of implementing stay-at-home order, the average distance traveled within the state was also found to decrease by 25-40%. Further, a modelling study of Brauner et al. (18) gathering data of 41 countries using NPIs estimated that stay-at-home orders (with exemptions) reduced the mean percentage of R_t by 10%. Moreover, in SAGE report (21), it suggested that the country lockdown was very impactful and could reduce R_t from 2.7 to 0.6 while 2-3 week short stay-at-home order had moderate impact in reducing R_t to below 1. As with all other measures, the earlier the stay-at-home order was implemented, the higher the impact.

Implementation points of time and impact on the pandemic curve

Nearly all findings found that a timely implementation of measures could reduce the transmission risk significantly. The relationships between the timing and the change rates of daily confirmed-cases were analyzed with a time-series. Marschner et al. (29) used Australia data to back-project that there was a fivefold increase in total infections if social distancing measures were delayed by one week. Consistently, in Du's study (26), a 1-day delay in implementing the 1st intervention was expected to

prolong an outbreak by 2.41 days. However, earlier lockdown, simulated by Islam et al. (11), showed a larger reduction in COVID-19 incidence compared with a delayed one after other social distancing interventions were initiated. Thanks to another empirical study based on the Oxford COVID-19 Government Response Tracker (30), some ideas can be grasped when deciding how to implement a measure earlier. It tracked Rt temporally for two weeks following the 100th reported case in 140 countries and observed the median timing among them, finding that lockdown measures and travel bans were considered early if they were implemented around two weeks before the 100th case and a week before detecting the first case respectively (30).

In addition, social distancing measures had a progressive control impact on the growth rates of daily confirmed cases, with Courtemanche et al. (31) showing reductions of 5.4%, 6.8%, 8.2% and 9.1% after 1-5 days, 6-10 days, 11-15 days, 16-20 days, respectively following the roll-out of the measures. The timing effect was further illustrated by Thu et al. (32) that social distancing interventions took 1-4 weeks to have an effect on the decline in number of infected cases among the 10-studied countries. For those countries with higher growth rates at the beginning may have more difficulties in controlling the transmission, and vice versa for those countries with initial lower growth rates. For example, China, Iran and Turkey, promulgating the most stringent level of social distancing measures, with initial infection growth rates apparently lower at around 60-70%, had the highest decline rates at 71%, 51.8% and 50.8% respectively while the U.S. and the U.K., having the highest initial growth rates (99.9%), experienced significantly lower decline rates of 14.8% and 25.9% respectively. The result suggested that social distancing measures could be more effective when being introduced earlier under situations with low growth rates.

Discussion

This scoping review covered a board range of social distancing interventions and outcome indicators. A comparison of the major outcomes of different levels of measures is shown in Table 3. Outcomes were mainly indicated by changes in Rt, incidence and mortality, along with indirect indicators such as daily contact frequency and travel distance. There was adequate empirical evidence for the effect of social distancing at individual level. The evidence was also adequate for partial or full lockdown at community level. However, the evidence was inconsistent for school closure and public transport restriction as a single type of intervention. The evidence was also very limited for workplace/business closures.

(Insert Table 3 here)

Many studies showed the combined effects of different social distancing interventions which were usually implemented as a package with 3-5 measures. Observed impact by an individual measure was scarcely reported or only demonstrated with modelling. For example, Islam et al. (11) reported that among 149 countries being studied, 118 countries covered 5 measures while 29 countries used 3 to 4 interventions, with only 1 country introducing 2 measures and the remaining 1 country using a single measure. In addition, even though the lockdown, in this review, was shown with the highest reduction in R_t, it had indeed been used along with multiple measures.

Apart from types of interventions, relationship between implementation time points and effect were investigated. Lam et al. (33); observed an early public health measure promulgation was able to contain the epidemic in Hong Kong, without initiating extreme measures such as a city-wide lockdown. Other studies suggested that the effect time variation might be due to the different times and levels of promulgating the social distancing measures, making the effectiveness apparently different (32). It

could be demonstrated through the comparison between countries showing that the stronger the level of social distancing, the faster it took to reduce the number of daily confirmed cases (32). Furthermore, high initial infection incidence due to late implementation of measures would reduce the effectiveness of measures (32). All these results indicated a need of rapid response and stringent measures to win the battle.

The effectiveness of social distancing measures was also affected by the contextual factors such as compliance, social belief and cultural factors. In addition, the personal behaviors such as wearing masks and improving personal hygiene as well as implementing border control also played a key role.

Contextual factors

Although social distancing measures impacted the pandemic curve, there are also other factors such as contextual factors including compliance, social belief and cultural factors contributing to its effectiveness. Low public compliance may be a key explanation that interventions showed no sign of flattening its curve. The compliance issue was further supported by Cruz's study (34) examining that the social distancing index (SDI), a social distancing adoption index used by the Brazilian government, larger than 55% was needed to reduce the daily death number. Moreover, social belief such as awareness of disease information might cultivate a sense of self-imposed initiation of handwashing, wearing protectives, purposely keeping a distance from people and reducing outdoor activities. Cultural factors may also have the influence on public gatherings, although it was too complicated for a quantitative evaluation regarding various timings, magnitudes and processes that have been happening in a region. Cultural factors were firstly studied in Huynh's study (35) illustrating that countries with higher Uncertainty Avoidance Index (UAI) predicted a smaller proportion of people gathering in public such as grocery and retail stores, pharmacy stores, recreation areas, public transport

and workplaces whereas countries in the northern European such as Finland, Sweden, and Norway with lower uncertainty avoidance indices were unlikely to follow with social distancing measures. Further, Islam's study (11) observed greater case reduction associated with those countries with a higher GDP per capita, a higher proportion of population aged 65 years or above, and stronger preparedness for the pandemic in terms of country health security index. Therefore, the cultural determinants are likely to play an important role in controlling infection behaviour.

Personal behaviour and border control

There are other measures that might be useful to suppress the virus spread, such as changes of personal behaviours including wearing face masks and improving personal hygiene. Border control is also one of the main interventions being used to contain the pandemic. These measures might have confounding effects to that of social distancing. A linear regression model by Zhang R et al. (36) showed a daily new infection in New York decreasing with a slope of 106 cases per day, with a decreasing rate equal to around 3% of daily new infections, after the mask-on policy. In contrast, the U.S. (excluding New York) increased with a slope of 70 cases per day, corresponding to an increasing rate at around 0.3% of daily new infections, as no such policy was implemented. The authors argued that the sharp difference between the growth rates of the daily new infections of New York and the U.S. (excluding New York) confirmed the effectiveness of use of mask. In addition, their research also brought out the mask-on policy in helping reduce the infection cases by over 75,000 from April 6 to May 9. Overall, it was proposed that mandated face covering effectively prevented airborne transmission by blocking atomization and inhalation of virus-bearing aerosols. Apart from using face coverings, hand hygiene was also commonly used during the pandemic to reduce acute respiratory illness, increasing the odds to 16% (35). Adherence to respiratory/hand hygiene measures were strongly recommended and its effectiveness would probably increase in combination with other measures (12). Further, border

control is also a measure widely used by many countries to block the importation from cases. Lai et al. (37) observed a reduction of median Rt from 1 to 0.75 after successive implementations of border control measures within 5 weeks by closing air-based and land-based borders and finally introducing mandatory quarantine to travellers from China, showing the importance of border control in limiting the infection.

Knowledge gap for future research

Due to the heterogeneity of the outcomes adopted in the studies, it is difficult to render direct comparison of the changes in Rt and incidence. Consistent inclusion of these outcomes in studies of similar kinds may allow systematic review and meta-analysis in further studies.

Few studies have investigated the effect of closure of entertainment and eatery settings. The SAGE report (21) suggested that the closure of gyms, bars and restaurants were useful since the environmental risks linked to higher probability of touch surfaces, higher aerosol generation and breathing rates due to aerobic activities. Specifically, the risk in bars and pubs was likely to be higher than many other indoor settings due to close proximity of people, long exposure duration, no wearing of face coverings and talking loudly. Some venues were poorly ventilated, especially in winter. In addition, consumption of alcohol impacts on customers' behaviors. More empirical evidence focusing on the dynamic among the environment, customer behaviors and transmission risks would be beneficial.

Some researchers proposed strategies to be proven by empirical evidence. A circuit breaker, proposed in the SAGE report (21), referring to 2-3 week short-time lockdown, could put the epidemic curve back by about 28 days or more. Based on historical evidence from the 1918 flu pandemic, Correia et al. (38) argued that regions taking earlier and aggressive social distancing measures grew faster economically in the post-pandemic period although there were adverse effects on the economy during

the pandemic period. Thus, predicting the recovery in an economy or a community based on the effectiveness of each intervention would be a matter of continuing concern.

Fatigue of pandemic prevention was seen everywhere during the course of COVID-19 pandemic which may exacerbate the peaks and resurgence following the relaxation of self-imposed measures and undermine the public acceptance to the advice from authorities. Governments with good risk communication with the public, hinging on engagement, communication and feedback, would be essential to help individuals assess and reduce their own risks appropriately. Abel et al. (39) reported that social distancing might lead to depression and anxiety in some people, which in return have an impact on social stability. Psychological impacts were not only observed on patients, health care workers but also on the overall population. However, Kim et al. (40) suggested we should routinely provide psychological support instead of stopping social distancing measures. Future studies should explore the long term strategies for risk communication and risk analysis in specific settings to overcome public fatigue towards social distancing. Response measures should be proportional to the risk in different settings.

Limitations

Although a lot of information about the measures taken was collected in government websites, measures being used in small localities or regional areas were not widely publicized or difficult to access, resulting in relevant studies being very limited. Moreover, there was a wide variation of testing accessibility and the criteria for who should be tested in different countries. Similarly, the points of time of promulgation and severity level of interventions are different among countries. Therefore, the cumulative confirmed cases might not reflect the actual situation of population and were not accurate for comparisons. Using a time series analysis referencing to the date of death but not to the date of testing done will be under a possible variation of case reporting and might hinder the decision making

process as long as 15-days delay in some countries. Another concern is that some studies used mobile device for people attendance changes in specific times and locations. The drawback was the unknown characteristics of those persons using mobile devices such as age and gender etc. The data only tracked mobile devices but not persons, who might have multiple devices (e.g., a phone and a tablet), or might not take their devices when they leave home. Hence, the results might not reflect the actual mobility patterns. Finally, our review excluded non-English literature. The English literature of COVID-19 might be biased towards countries with good research capacity and interests in publishing their findings for international audience.

Conclusions

Our review showed that the outcomes of social distancing measures were mainly measured by changes in R_t, incidence and mortality. There was empirical evidence for the effect of social distancing between individuals, and for partial or full lockdown. However, the evidence was inconsistent for the separate effect of school closure and public transport restriction, and it was very limited for workplace/business closures. In the community setting, there was more evidence on the combined effect of different social distancing interventions than for a single one. Apart from the effectiveness of the interventions, public compliance is another important issue. COVID-19 has been changing our lives and a new norm may emerge as we have to live with new variants of the virus, which may develop to a situation similar to that of the seasonal flu, where a total elimination is not the goal. Fatigue of preventive behaviors is on the top of the public health agenda. Community compliance with social distancing measures is related to the population's attitude to government policies, the access/awareness of trustful sources of information, the initiations and maintenance to self-imposed measures. Therefore, risk communication and risk analysis continue to be the cornerstone of public health measures and need to be in conjunction with addressing the research gap for implementing effective measures which are targeted and proportionate to the risk in different settings.

Figure:

Figure 1. PRISMA flow diagram of literature search and selection

Contributors

EKY designed the study, applied for the grant and made major contributions to writing the manuscript. VCHC, EKY, KSS and CTH managed the review methodology. TSML, KSS and YSL conducted the review and data synthesis. TSML, KSS, EKY, CHKY and CTH wrote the first draft of the manuscript. All authors read, revised and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Ethics approval

Ethical approval was obtained from the Survey and Behavioural Research Ethics Committee of the Chinese University of Hong Kong (Ref no. SBRE-19-595).

Consent for publication

Not applicable.

Data sharing statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Table 1 Article characteristics (n=34)

		Count (%)
Countries/ cities by geographic region		
	Asia	12 (30.0)
	Australia & New Zealand	1 (2.5)
	Europe	9 (22.5)
	North America	12 (30.0)
	South America	3 (7.5)
	Global studies	3 (7.5)
Country economy[#]		
	High income	26 (59.1)
	Middle income	15 (34.1)
	Low income	3 (6.8)
Article type		
	Research article	31 (91.2)
	Review article	3 (8.8)

[#]Country economy level according to The World Bank's classification.

Table 2 Effectiveness and outcomes of social distancing measures

Article and Study Characteristics		Type of Social Distancing Measures						Effectiveness Indicators
Authors; article type; study period/ publication date	**Country/ region; economy level**	**Social distancing between individuals**	**School measure / closure**	**Workplace measure / closure**	**Public transport restriction**	**Stay-at-home recommendation / ordinances**	**Others**	**Infectivity:** Rt, effective reduction number **Incidence:** incidence, incidence rate, attack rate, bed occupancy rate **Mortality:** Mortality or fatality rate **Effect time:** Action and effect duration, time of reaching peak **Attendance:** Attendance % of location, daily vehicles miles, daily contact frequency, mobility of leaving home, travel distance
Auger et al.(23) Research Article; 9/3/2020-7/5/2020	The US; High		Statewide closure of primary and secondary schools					**(Incidence & mortality):** Primary and secondary school closure in the US between March and May 2020 was associated with decreased COVID-19 incidence (adjusted relative change per week, −62%) and mortality (−58%). States that closed schools earlier, when cumulative incidence of COVID-19 was low, had the largest relative reduction in incidence and mortality, although there might be confounding effects from other interventions.
Brauner et al. (18). Research Article; 22/1/2020-30/5/2020	Members of the EU countries; High	Limiting size of gathering		Closing most of non-essential businesses and high risk businesses, e.g. bars and restaurants				**(Infectivity):** 41 countries-pooled data showed Rt reduction of 36% when gatherings were limited to 10 people or below; 28% when 100 or below and 13% when 1,000 or below. A 29% R_t reduction came with closing most of non-essential businesses while 20% was found when closing high risk businesses, e.g. bars and restaurants.
Castaneda-Babarro et al. (41); Research article; 23/3/2020-1/4/2020	Spain; High	✓	Forced e-learning		Restricted travel	Country lockdown with stay-at-home measures		**(Attendance):** Self-reported walking time decreased by 58.2% during confinement.
Clipman et al. (20); Research article; 17–28/6/2020	Maryland, the US; High	✓						**(Incidence):** Multivariable analysis found that history of SARS-CoV-2 infection was significantly less common among those who always practiced social distancing (aOR for indoor social distancing, 0.32 [95% CI, .10–

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								.99]; aOR for outdoor social distancing, 0.10 [95% CI, .03–.33].
Cruz (34); Research article; 15/3 to 5/4/2020	São Paulo City, Brazil; Middle	✓	Mandatory closure	Work-from-home and mandatory closure of non-essential businesses				**(Mortality):** Correlating daily death number with Social Distancing Index (SDI) was derived from government websites. SDI was between 52% and 56%, crossing the break-even point of death number (from 0.82 to -0.4). SDI larger than 55% is needed to reduce death number.
Courtemanche et al. (31) Research article; 1/3 – 27/4/2020	The US; High	Ban on large social gathering with a limit of 50 people	Public school closure	Closing entertainment businesses		Shelter-in-place order (last policy)		**(Incidence):** Growth rate of daily confirmed cases reduced by 5.4% after 1-5 days, 6.8% after 6-10 days, 8.2% after 11-15 days, 9.1% after 16-20 days. The number of confirmed cases was 10 times greater without shelter-in-place order and 35 times greater without 4 types of social distancing measures.
Du et al.(26); Research article; 1/1 - 15/2/2020	58 cities of China; Middle	Ban on public gathering	✓	Closing shopping malls, restaurants and entertainment businesses	Suspension of intracity and intercity public transport	✓	Testing	**(Infectivity):** Rt declined by an average of 54.3% (+/- 17.6%) during the containment period. **(Effect time):** The mean time until successful containment was 21 days after the 1st reported case and 8 days following the initiation of interventions. During the period of containment, the R_t declined by an average of 54.3%. A delay of 1 day in implementing the 1st intervention is expected to prolong an outbreak by 2.41 days (95% CI 0.96–3.86)
Huynh (35); Research article; 16/2 - 29/3/2020	58 countries; Low to high	Social distancing in: 1.retail and recreation 2.grocery and pharmacy						**(Attendance):** Attendance in percentage change of specific locations was reported. Countries with higher Uncertainty Avoidance Index (UAI) predicted lower proportion of people gathering in public such as retail and recreation, grocery and pharmacy, parks,

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		3.parks 4. transit stations 5.workplaces 6.residential areas						transit stations, workplaces. Northern Europe (Finland, Sweden & Norway) with lower UAI was unlikely to commit to social distancing. The cultural determinants played an important role in controlling infection behaviour.
Islam et al. (11); Research article; 1/1– 30/5/2020	149 countries; Low to High	Restriction of mass gathering and public events	School closure	Workplace closure	Public transport closure	Movement Lockdown		**(Incidence):** Overall, with any intervention, there was 13% reduction in incidence. Data suggested similar effectiveness when school closures, workplace closures, and restrictions on mass gatherings were in place. Earlier lockdown was associated with a larger reduction compared with a delay after other interventions were in place. A combination of 4 measures including restrictions on mass gatherings, school closures, workplace closures, and lockdowns in 32 countries was associated with decreasing incidence of COVID-19 (pooled incident rate ratio, IRR 0.87, 0.84 to 0.91).
Jarvis et al.; (42) Research article; 24/3-27/3/2020	The UK; High		School closure	Limiting time at work, having work closed and/or not visiting work			Quarantine and isolation isolate	**(Attendance):** A 74% reduction in the average daily number of contacts was observed per participant (from 10.8 to 2.8). It was expected to be sufficient to reduce R0 from 2.6 before the lockdown to 0.62 (95% confidence interval [CI] 0.37–0.89) after the lockdown, based on all types of contact and 0.37 (95% CI = 0.22–0.53) for physical contacts only.
Juni et al.(43); Research article; 7– 13/3/2020	144 countries; Low to High	Gathering of any size	✓	Closing restaurants, bars, or non-grocery stores				**(Incidence):** A rate ratio comparing the cumulative count of confirmed COVID-19 cases with that of previous week was reported. There was strong association of

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								epidemic growth with mass gathering (RRR 0.65, 95% CI 0.53-0.79), school closure (RRR 0.63, 95% CI 0.57-0.78), business closure (RRR 0.62, 95% CI 0.45-0.85).
Khanna et al.(44); Review; Published on 10 April 2020	China, HK, Singapore, South Korea, US, Italy, Spain, Iran and India; Middle to High				All transports in and out of Hubei were prohibited, with each citizen being allowed to go out for 30 minutes every two days	3-week lockdown in Hubei	Quarantine of mild and asymptomatic cases for China Travelers	**(Infectivity):** China Rt reduced from 2.35 to 1.05 during the period of 16/1/2020–30/1/2020. **(Effect time):** China slowed the dispersal of infection to other cities by 2.91 days and increased the doubling time from 2 to 4 days. Other Chinese cities implementing preventive control measures earlier were reported 33.3% fewer cases in the first week of their outbreaks compared with that of cities starting the control later.
Koh, et al. (30); Research report; 1/1/2020-28/5/2020	142 countries; Low to High	Cancellation of public events, restrictions on size of gatherings,	✓	Closure of workplace	Closures of public transport	Stay-at-home order	Restrictions on internal movements/ international travel	**(Infectivity):** Following the 100th case, it was found effective that complete travel bans and all forms of lockdown-type measures reduced average Rt over the 14 days. Stay-at-home recommendation and partial lockdowns were as effective as complete lockdowns when controlling the outbreaks. However, these measures were effective when it could be implemented early.
Lai et al. (37); Research article; 23/1 – 1/3/2020	Hong Kong; High		✓	Work from home			Border Control • Phases 1-3: (18/1-7/2) • Phase 4: (8-29/2) Mandatory quarantine for	**(Infectivity):** Median Rt dropped from 1.07 to 0.75 with border control in phase 4 (8–29/2/2020).

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							China travelers in phase 4	
Lam et al.(33); Research article; 1/1 – 31/5/2020	Hong Kong; High	Cancellation of large scale events	School suspension from phases 1-4	Work from home for civil servants in phases 1 & 2			Entry restriction / quarantine for inbound travelers and asymptomatic testing	**(Mortality):** Case fatality ratio (0.4%) was much lower than global ones during the same period in WHO (6.1%).
Lasry et al.(45); Research article; 26/2 – 1/4/2020	4 US metropolitan areas: San Francisco, Seattle; New Orleans, and New York City; High	Ban on gathering of certain size	School closure	Restrictions on businesses		Stay-at-home orders (last policy)	States of Emergency (1st policy)	**(Attendance):** Mobility of leaving home was reported. In four localities, the percentage leaving home was close to 80% on February 26, and decreased to 42% in New York City, 47% in San Francisco, 52% in Seattle, and 61% in New Orleans on April 1. Mobility did not decline following the state of emergency alone but a combination of policies such as gathering restrictions or school closures and further decreased after stay-at-home orders. **(Incidence):** 3-day average percentage change in cumulative case count showed a decreasing trend by the last 2 weeks of March after a set of policies implemented.
Lino et al. (5); Research article; 1-31/5/2020	Fortaleza (state capital city), Ceará, Brazil; Middle	✓		Suspension of commercial activities	Restricted daytime movements and interruption of intercity trips	City lockdown, night curfews		**(Incidence)** Bed occupancy rates in a tertiary hospital for referred COVID-19 cases were higher than 100% before the lockdown and reached nearly 140% 2 days after. The rate decreased to below 100% 14 days after the lockdown (viral incubation period), and dropped to about 85% 23 days after the lockdown onset.

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Marschner (29); Research article; 25/1 – 8/5/2020	Australia; High	Stage 2: limiting gathering of 2 people (26-31 March)		Stage 1: prohibited face-to-face meeting and entertainment activities (23 March)		Stage 3: prohibited leaving home (26-31 March)	Border control (20 March)	**(Effect time):** It was estimated that one week delay in control measures would lead to an almost fivefold increase in total infections but one week earlier control would reduce total infections of similar magnitude.
Munayco et al.(46); Research article; 23/1– 9/5/2020	Peru; Middle	Ban on gathering of larger than 300 people on 12 March	School measure since 11/3				Closing country border, National Emergency Declaration on 16 March	**(Incidence):** Before the implementation of social distancing measures in Lima, the mean scaling of growth parameter, p, was estimated at 0.9 and the reproduction number at 2.3. School closures and other social distancing interventions slowed down the spread of the novel coronavirus, shifting the exponential growth trend to an approximately linear growth trend, with the scaling of growth parameter being reduced to 0.53.
Pan et al.(28); Research article; 8/12/2019– 8/3/2020	China Wuhan; Middle	Social distancing			Traffic restriction	Cordons sanitaire	Universal symptom survey, home and centralized quarantine	**(Infectivity):** A reduction of Rt from larger than 3 in January to less than 1.0 on February 6 and then less than 0.3 in March after implementation of measures by different phases.
Patel P et al.(47); Research article; 30/1– 4/5/2020	India; Middle	✓	✓	✓		Lockdown since 25 March	progressive travel restriction, health promotion and enhanced testing	**(infectivity):** A decline in Rt following NPIs implementation was observed, with a reduction from 2.51to 1.83 at the end of lockdown phase. Although the sub-exponential growth confirmed mitigation of epidemic, Rt larger than 1 still indicated ongoing disease transmission.
Rivkees et al. (22); Brief report;	Florida, US High	✓	Closures of elementary	Restricted access to bars and	✓	Statewide stay-at-home order		**(Attendance)** Assessment of movement within the state using Google mobility and Unacast mobility analytics based on cell

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1/3/2020-31/5/2020			schools, high schools, and universities for in-person classes	restaurants, limited commerce to essential businesses				phone data showed that closing schools resulted in a 40-55% reduction in average distance traveled compared with pre-outbreak levels. The stay-at-home order was associated with a further reduction in average distance traveled. During the period under stay-at-home order, the density of in-person encounters fell by 74-82%, visits to nonessential venues by 55%, and overall distance traveled by 45%. Average distance traveled within the state decreased by 25-40%.
Saez et al. (48) Research report; 17/1/2020-5/4/2020	Spain High	Reducing travel, avoiding crowded places, using non-contact greetings	✓	Closure of workplaces, stadiums, cinemas, theatres and restaurants		✓	Quarantines, travel restrictions	After implementing the measures for one day, the variation rate of accumulated cases decreased daily by 3.059 percentage points on average (95% credibility interval: −5.371,−0.879) and the decline was greater when time passed and reached 5.11 percentage points on the last day of data collection. Despite not entering the decrease phase, the measures taken by the Spanish Government on March 14, 2020 managed to flatten the curve.
Siedner et al. (24); Research article; 10/3/2020-26/5/2020	All 50 states of the US, High	Statewide social distancing measures with cancellation of public events	✓	✓	Restrictions on internal movement and closure of state borders			**(Incidence)** The mean daily COVID-19 case growth rate dropped by 0.9% per day, starting 4 days after implementation of the first statewide social distancing measures. **(Mortality)** After implementing social distancing for 7 days, the COVID-19-attributed mortality growth rate fell by 2.0% per day, although this decline was no longer statistically significant by 10 days.

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Thu et al.(32); Research article; 11/1 - 2/5/2020	10 countries: the US, Spain, Italy, UK, France, Germany, Russia, Turkey, Iran and China; Middle to High	Cancellation of public events	✓	Work from home, cancellation of non-essential events	Domestic transportation restriction	By region and, by nationwide, by different phases	Entry restrictions to those from highly infected areas	**(Incidence):** Growth rates of daily confirmed cases in the UK and the US were the most severe, at 99.9%, followed by Spain at 99.2%, France at 96.2%, Italy at 95.4%, Germany at 85%, Russia at 72.2%, Turkey at 70.7% and Iran at 62.8%. Countries with high growth rate showed lower decline rate, showing longer time needed for those countries to control the epidemic by social distancing measures.
Vokó et al.(49); Research article; 1/2/2020-18/4/2020	28 European countries; High	Social distancing with public event ban	✓	✓	✓	✓		(Incidence) Incidence of new COVID-19 cases grew by 24% per day on average before the changepoint. From the changepoint observed, the growth rate was reduced to 0.9%, 0.3% increase, and to 0.7% and 1.7% decrease by increasing social distancing quartiles based on Social distance index (SDI) calculated based on Google Community Mobility Reports.
Wan et al.(25); Research article; 20/1/2020-3/3/2020	Mainland of China excluding Hubei; Middle	Social distancing and self-isolation			✓		Close contact tracing, body temperature measurement	**(Infectivity)** Rt has dropped sharply from 3.34 on 20 January 2020 to 0.89 on 31 January 2020, after integrated control strategies were implemented.
Weill et al. (19); Research article; 1/1/2020-21/4/2020	The US; High	✓		business closures		Safer-at-home orders		**(Attendance):** Median distance traveled, retail and recreation, locations visited by a mobile device per day showed a sharp decrease in March after the implementation of social distancing measures, with the wealthier areas decreasing mobility more significantly than poorer areas. However, the trend shifted reversely after March regarding completely staying at home. People from

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								wealthier areas shifted from the lowest before March to the most likely to completely stay at home after March, vice versa for those in poorer countries.
Wilasang et al.(50); Research article; From the date of 100 cases to 7/4/2020	10 countries: Belgium, China, France, Germany, Iran, South Korea, Spain, Thailand, US and UK; Middle to High	✓				✓	Active case finding	**(Infectivity):** After 3-week control measures, only China and South Korea were successful in controlling the disease (Rt<1), while the others were unsuccessful. The study observed that countries with active case finding and prompt isolation could have a reduction in the reproduction number more rapidly.
Yehya et al.(51); Research article; 21/1-29/42020	The US; High		School closure				Declaration of Emergency	**(Mortality):** Each day of delay of either intervention increased mortality risk by 5- 6%.
Zhang et al.(27); Research article; 24 – 30/12/2019 as baseline and 1-10/2/2020 as outbreak period	Wuhan and Shanghai; Middle		✓		✓			**(Attendance):** Daily contact frequency in Wuhan showed a reduction from 14.6 to 2.0 while Shanghai from 18.8 to 2.3. The trend was consistent with mobility data of an 86.9% and a 74.5% drop in Wuhan and Shanghai respectively.
Zhang et al. (36); Research article;	Wuhan (China), Italy and the US;	✓				Stay-at-home	Face mask	**(Incidence):** Daily new infection in New York decreased with a slope of 106 cases per day (decreasing rate at around 3%) after face mask-on policy, while US (excluding New

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23/1– 9/5/2020	Middle to High							York) increased with a slope of 70 cases per day (increasing rate at around 0.3%). The decreasing rate in the daily new infections in New York with face covering mandate was proportionately higher than that in the United States with only social distancing and stay-at-home order, illustrating the importance of face covering on stemming the virus spread. With mask-on policy, Italy showed an infection reduction by over 75,000 from April 6 to May 9.
58th SAGE meeting summary (21); Review;	The UK; High					Lockdown, short stay-at-home order		**(Infectivity):** Lockdown was very impactful and reduced Rt from 2.7 to 0.6. 2-3 week short stay-at-home order had moderate impact on reducing Rt to less than 1. Both showed high confidence correlation.
		Decreasing contact between households, closure of worship/ community centers, restriction on outdoor gatherings						**(Infectivity):** Moderate impact was found by stopping contacts among different households, reducing Rt by around 0.1-0.2. Low to moderate impact was shown following closure of worship/ community centers, with a potential reduction in Rt up to 0.1. Low impact came with the restriction on outdoor gatherings, with Rt being reduced to less than 0.05, considering the frailty of SARS-CoV2 under well-ventilated environment.
					Local 5-mile travel restriction, use of public transport			**(Infectivity):** The impact of 5-mile travel restriction was considered as low to moderate, with limited benefit especially when local outbreak was widespread. Restricted use of public transport to key workers might have low impact due to low

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					restricted to key workers			level of crowding, mandated face-mask policy and inconclusive evidence of the transmission risk in public transport.
			Mass / reactive school closure, closure of class with infection, alterative school schedules with half class sizes, closure of further/ high education or childcare					**(Infectivity):** Moderate impact of closing all schools was found, with a reduction in Rt of 0.2~0.5 while closing secondary schools was considered to be more effective, with a Rt drop of 0.35. Reactive school closure might have a moderate impact on the reduction in Rt of 0.12 ~ 0.45 whereas low to moderate impact was estimated for reactive closure of class with infection. Alternative school schedules with reduced class size were suggested to have moderate to low impact. Closure of further / higher education associated with moderate impact while closure of childcare might have low to moderate impact.
				Work from home, alternate work, closure of bars/ pubs/ cafes/ restaurants, closure of gym/ leisure centers, non-essential retail, personal services, adherence to “COVID				**(Infectivity):** Moderate impact of work from home was evaluated with a Rt reduction of 0.2-0.4 if all people followed while low to moderate impact with a Rt drop up to 0.1 was estimated for alternate work. Moderate impact with potential reduction in Rt of 0.1-0.2 was predicted for the closure of bars/pub/restaurants. Closure of gym/ leisure centres associated with low to moderate impact, with potential reduction in Rt of up to 0.1. Impact of closure of non-essential retail and personal services was estimated to be limited. Adherence to “COVID security” in workplaces such as

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				security" arrangement in workplaces				improved hand/ surface hygiene and added barrier setting was also considered as low impact.
ECDC (12); Review; Published on 24 Sept 2020	Members of the EU countries; High					Stay-at-home		**(Infectivity):** Rt reduced by 18% (ranging from 4-31%).
		Physical distance between 1-2m						**(Infectivity):** Physical distancing of 1 metre or more was linked to an approximately five-fold reduction of the transmission risk, with the protective effect being doubled for every extra metre added.
					Domestic travel restrictions: a cordon sanitaire or public transportation closure			**(Infectivity):** There were contradictory results on Rt among the studies. Modelling showed strong association while other studies showed no impact unless other NPI was put in place, e.g. physical distancing. It was difficult to relate observed changes in transmission dynamics to a single measure.
			School closure					**(Incidence):** Observational data suggested that reopening schools has not been associated with significant increases in community transmission.
				Work from home, flexible working time and social distancing measures, closure of non-essential businesses				**(Infectivity):** There was a 40% Rt reduction by closing most of non-essential businesses while 31% by closing high risk businesses, e.g. restaurant/ bars/ nightclub/ cinemas/ gym.

Table 3 Comparison of the outcomes of different levels of social distancing

	Social distancing between individuals	School closure	Workplace measures	Public transport restriction	"Partial" lockdown	Full lockdown
Evidence amount	Adequate	Moderate; inconsistent findings	Limited	Limited	Adequate	Adequate
(Infectivity): Rt, effective reduction number	Physical distancing of 1 meter or more could reduce the transmission risk by 5 times and the protective impact was double for every extra meter (17). Estimated R_t reduced by 36%, 28% and 12% when gatherings were limited to 10, 100 and 1,000 people respectively (18).		Estimated 29% R_t reduction by closing most of non-essential businesses while 20% by closing high risk businesses (18).	No difference in reduction in R_t (11).	In Mainland China excluding Hubei (province of Wuhan), R_t dropped from 3.34 to 0.89 (25). In 58 cities of China, R_t dropped by 54.3% (26).	From data of 41 countries, estimated R_t reduced by 10% by stay-at-home orders (−2%–22%) (18). UK estimation suggested that country lockdown could reduce R_t from 2.7 to 0.6 while 2-3 week short stay-at-home order had moderate impact by reducing R_t to below 1 (21). China R_t reduced from 2.35 to 1.05 during the lockdown (44).
(Incidence): Infection incidence/ ratio of incidence rate ratio/ attack rate/ bed occupancy rate	In the US, COVID-19 infection was less likely among the public who always practiced social distancing (aOR for indoor social distancing, 0.32 [95% CI, .10–.99]; aOR for outdoor social distancing, 0.10 [95% CI, .03–.33] (20).	In the US, school closure decreased COVID-19 incidence (adjusted relative change per week, −62%) (23). Observational data from a number of the EU countries suggested that re-opening of schools was not associated with increase of community transmission (12).			In the US, mean daily COVID-19 case growth rate decreased by 0.9% per day four days after lockdown (24).	Data from 32 countries showed decreased incidence of COVID-19 (pooled incident rate ratio, IRR 0.87, 0.84 to 0.91) (11). Growth rate of daily confirmed cases reduced by 5.4% after 1-5 days, 6.8% after 6-10 days, 8.2% after 11-15 days, 9.1% after 16-20 days (31).

(Mortality): Mortality/ Fatality rate		In the US, school closure decreased COVID-19 related mortality (−58%) (23).			In the US, COVID-19-attributed mortality growth rate decreased by 2% per day seven days after lockdown (24).	
(Effect time): Action and Effect duration / Time of Reaching peak					In 58 cities of China, mean time until successful containment was 8 days (26).	
(Attendance): Attendance % of location/ daily vehicles miles/ daily contact frequency/ Mobility of leaving home/ distance travel		In Florida, the US found that closing of schools resulted in a 40-55% reduction in average distance traveled (22).			In Spain, self-reported walking time decreased by 58.2% (41).	In Wuhan and Shanghai, the average daily number of contacts dropped from 14.6 to 2 and 18.8 to 2.3 respectively during lockdown. Mobility dropped 86.9% and 74.5% in respective areas (27). Stay-at- home order in Florida of the US resulted in a reduction of in-person encounters by 74-82%, visits to nonessential venues by 55%, and overall distance traveled by 45% (22).

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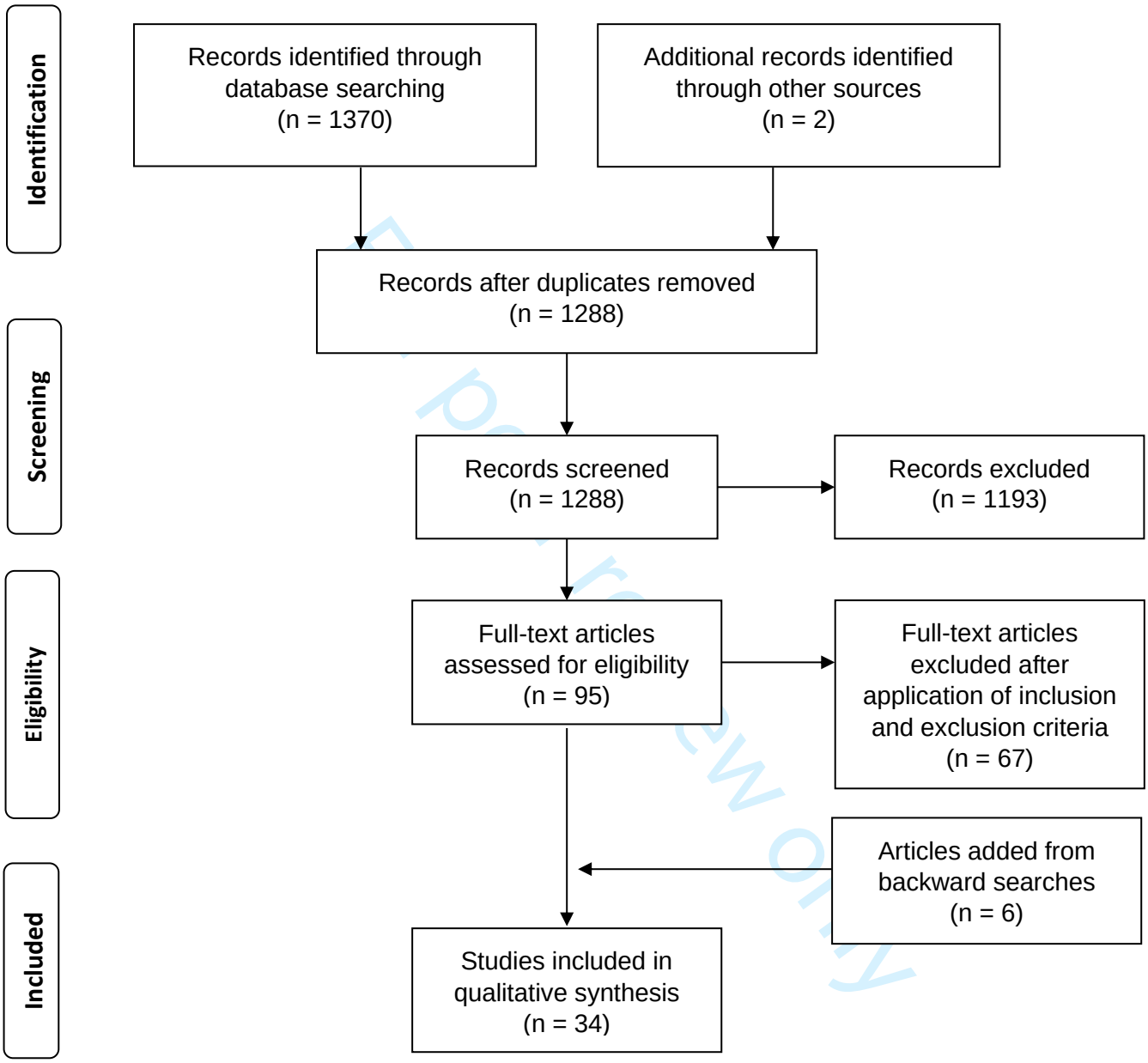
Figure 1. PRISMA flow diagram of literature search and selection



Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	4-5
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	5
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Click here to enter text.
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	6
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	6
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	6
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	6-7
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	7
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	8
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	Click here to enter text.

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	7
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	7
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	8-13, 24-35
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	Click here to enter text.
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	24-35
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	8-13, 36-37
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	13-14
Limitations	20	Discuss the limitations of the scoping review process.	18
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	19
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	20

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.
* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.
† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).
‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.
§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850.

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Effectiveness of different types and levels of social distancing measures: a scoping review of global evidence from earlier stage of COVID-19 pandemic

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Effectiveness of different types and levels of social distancing measures: a scoping review of global evidence from earlier stage of COVID-19 pandemic

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Abstract

Objective: Social distancing is the critical measure in the control of the COVID-19 pandemic before achieving herd immunity through effective vaccination of global populations. This scoping review aims to synthesize research findings on the effectiveness of different types and levels of social distancing measures in earlier stage of COVID-19 pandemic without confounding effect of mass vaccination.

Design: Scoping review.

Data sources: MEDLINE, Embase, Global Health and four other databases were searched for eligible studies on social distancing for COVID-19 published from inception of the databases to 30 September 2020.

Study selection and data extraction: Effectiveness studies on social distancing between individuals, school closure, workplace/business closures, public transport restriction and "partial"/full lockdown were included. Non-English articles, studies in healthcare settings or not based on empirical data were excluded.

Results: After screening 1638 abstracts and 8 additional articles from other sources, 41 studies were included for synthesis of findings. The review found that the outcomes of social distancing measures were mainly indicated by changes in Rt, incidence and mortality, along with indirect indicators such as daily contact frequency and travel distance. There was adequate empirical evidence for the effect of social distancing at individual level, and for partial or full lockdown at community level. However, at the level of social settings, the evidence was moderate for school closure, and limited for workplace/business closures as a single type of intervention. There was no evidence for the separate effect of public transport restriction.

Conclusions: In the community setting, there was stronger evidence on the combined effect of different social distancing interventions than for a single one. As fatigue of preventive behaviors is on the top of the public health agenda, future studies should analyze risk in specific settings such as eateries and entertainment to implement and evaluate measures which are proportionate to the risk.

Keywords: COVID-19, effectiveness, incidence, scoping review, social distancing

Strengths and limitations of this study

- Frist scoping review to synthesize findings on the effectiveness of social distancing measures for COVID-19 at individual, social settings and national levels in a variety of outcome parameters.
- This review shows the amount of evidence for different types and levels of social distancing measures.
- Findings in varied outcome parameters could not be compared directly.
- Non-English literature was excluded from this review.

Introduction

Social distancing is the most important measure to control the outbreak of COVID-19 worldwide before herd immunity can be achieved through effective vaccination (1). Social distancing, also known as physical distancing, is based on the premise that the rate of transmission of infectious diseases will decrease if people in communities stay at home from work or school, avoid large gatherings and refrain from having physical contact with one another. World Health Organization (WHO) guidelines describe social distancing measures at the individual level, e.g. keeping at least one meter from each other; at the community level generally, e.g. stay-at-home recommendation/ordinances; or in specific socio-economic settings e.g. measures for workplace, schools, eateries, entertainment and parties (2, 3). At the national or regional levels, lockdown (also called "community quarantine" to restrict movement of population groups) may be imposed as an extreme form of social distancing (4, 5), where it can be total or "partial" when key socio-economic activities are restricted (6).

Despite the fact that social distancing measures have become a crucial strategy globally to mitigate COVID-19 pandemic, the evidence for their effectiveness is just slowly accruing. Earlier studies applied mathematical modelling to predict effectiveness of social distancing measures (7-10). Recent studies evaluated the outcomes retrospectively using empirical data and reported the outcomes in specific parameters. A study analyzed data from 149 countries suggested that implementation of any social distancing intervention was associated with an overall reduction in COVID-19 incidence of 13% (IRR 0.87, 95% CI: 0.85 - 0.89) (11). It concluded that data from 11 countries indicated similar overall effectiveness (pooled IRR 0.85, 0.81 to 0.89) when school closures, workplace closures, and restrictions on mass gatherings were in place (11). The European Centre for Disease Prevention and Control (ECDC) also estimated the effectiveness of different types of social distancing in Europe. While most were based on prediction modelling, some retrospective analysis showed that lockdown reduced R_t from around 2.7 to around 0.6 in the UK (12). Given the different types, variations and

combinations of social distancing measures were implemented at different levels in different jurisdictions and pandemic contexts, it is important to study what parameters and methods were used and what outcomes were measured in various research studies. This is critical in a protracted pandemic after continuing restrictions to self-determinants and socio-economic life, which have led to fatigue in preventive behaviors. In this context, targeted measures which have been evaluated proportionate to the risks should motivate continuing preventive behaviors.

The aim of this study was to synthesize research findings on the effectiveness of different types and levels of social distancing measures during earlier stage of COVID-19 pandemic. The study was conducted as a scoping review to include a broad range of outcome parameters and study designs. This enables a better understanding the effectiveness of the spectrum of social distancing measures in controlling COVID-19 outbreak.

Methods

The scoping review method was applied to include a range of parameters relating to effectiveness of social distancing measures during COVID-19 pandemic. In contrast to a systematic review which answers a specific and narrow question, a scoping review aims to explore a set of emerging and diverse themes to synthesize the current evidence, clarify conceptual parameters and identify gaps for further research (13-15).

Eligibility criteria

Inclusion criteria for this review were studies that described: 1) effectiveness or outcomes of social distancing measures targeting the general public; 2) social distancing measures including those between individuals; targeted measures on including closures of schools, workplaces, restaurants and

bars, and other social settings; stay-at-home recommendation or ordinances, community quarantine and lockdown; and 3) quantitative research, secondary data analysis, modelling studies based on empirical data, and review articles.

Exclusion criteria were: 1) qualitative studies, commentaries, mini-reviews without search strategies, editorials, conference presentations, dissertations, and book chapters); 2) non-English articles; 3) studies in healthcare settings, such as those on healthcare workers, hospital patients and elderly nursing homes; 4) studies on the impact of social distancing measures on non-COVID-19 diseases and psychosocial health of the public; and 5) hypothetical/stimulation models predicting future trends of incidence.

Search strategies and study selection

Seven electronic databases including AMED, Embase, Global Health, MEDLINE, Ovid Nursing Database, APA PsycInfo, Social Work Abstracts were searched by an experienced team member in scoping and systematic reviews. The search period was from the inception of the databases to 30 September 2020. To enhance sensitivity, syntax of *"COVID*".m_titl. AND social distan*.ab* and *"COVID*".m_titl. AND physical distan*.ab* were used as search strategies to cover both terms of social distancing and physical distancing. Additional syntax of *"SARS-CoV-2*".m_titl. and (social distan* or physical distan*).ab.* were used to search for articles using the keyword 'SARS-CoV-2'. Details are shown in the supplementary file. Furthermore, backward searches from the reference lists of the articles to locate additional articles and reports. The search and selection process followed the Joanna Briggs Institute Methods Manual for scoping reviews, and the reporting was guided by PRISMA Extension for Scoping Reviews (PRISMA-ScR)(16). Two reviewers independently screened the titles and abstracts to assess their eligibility. Full texts of potential citations were retrieved for detailed examination. Selection discrepancies were settled through discussions between these two reviewers.

Any outstanding disagreements were resolved by consulting the third member. We did not conduct risk of bias assessment, which is consistent with recommendations from the Joanna Briggs Institute Scoping Review Methods Manual and PRISMA-ScR (16). Different from a systematic review, a scoping review aims to provide an overview of the existing evidence comprehensively, regardless of risk of bias of included studies (16).

Data extraction and synthesis

For each study included, texts under the headings of 'results' or 'findings' were extracted and analyzed by two reviewers. The analysis was performed by one reviewer and verified by a second reviewer. The two reviewers reached consensus upon the outcomes reported and the classification of their types of social distancing and effectiveness indicators.

Patient and public involvement statement

It was not appropriate or possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research

Results

Study selection and characteristics

We screened 1638 abstracts from our electronic search on the databases with 2 additional research reports being identified from governmental websites. Of the 120 full texts retrieved for further assessment, 35 articles fulfilled our eligibility criteria. In addition, 6 relevant studies were identified from the reference lists of the articles through backward searches. Hence, in total, 41 studies were included in this review. Figure 1 presents results of the literature search and classification flow, and Table 1 provides detailed characteristics of the selected articles.

(Insert Figure 1 and Table 1 here)

There were 38 research studies and 3 reviews. Fourteen studies reported data from North America, another 13 from Asia, 12 from Europe, 3 from South America and 2 from Australia. There were also 3 global studies which reported data from over 50 countries in multiple regions. According to the classification by World Bank (15), 63.5% of the studies were from high-income countries/regions, 30.8% from middle-income and 5.8% from low-income countries/regions.

Table 2 summarizes the key findings based on the effectiveness indicators including the following aspects: 1) Infectivity: R_t, effective reduction number; 2) Incidence: infection incidence, ratio of incidence rate, attack rate, or bed occupancy rate; 3) Mortality or fatality rate; 4) Effect time: action and effect duration, time of reaching peak; 5) Attendance percentage of location, daily vehicles miles, daily contact frequency, mobility of leaving home, or travel distance. A description of each type of intervention is also given. A tick "✓" is put if no detailed elaboration was provided in the reviewed articles.

(Insert Table 2 here)

Social distancing at individual level

Social distancing measure was usually achieved by the prohibition of mass gathering in public areas and/ or maintaining certain physical distance between people. Most studies reported a positive relationship between the transmission risk and certain level of social distancing. A meta-analysis including seven studies on COVID-19 concluded that physical distancing of 1 meter or more was effective to reduce the transmission risk by 5 times and the protective impact was double for every extra meter (17). Similarly, based on the chronological data on interventions in 41 countries between

January and May 2020, Brauner et al. (18) estimated that Rt reduced by 36%, 28% and 12% when gatherings were limited to 10, 100 and 1,000 people respectively. Furthermore, studies also found how mobility changed according to different social distancing measures. A study by Weill et al. (19) in the U.S. found that median distance traveled, retail and recreation locations visited by a mobile device per day showed a sharp decrease in March 2020 after the implementation of social distancing measures in the country, while percentage of completely staying at home doubled. Similar results also showed that a decline in visits to nonessential businesses following the implementation of social distancing was associated with a drop in estimated Rt (20). In the analysis of 211 US counties, visits to nonessential businesses reduced by 50% and 70% would contribute to a 45% decline in Rt and a drop of Rt to a threshold of 1.0 respectively, indicating the larger the drop in nonessential business visits, the more significance in the fall of a Rt (20). Another US study by Clipman et al. (21), in Maryland, found that history of COVID-19 infection was significantly less likely among the public who always practised social distancing (aOR for indoor social distancing, 0.32 [95% CI, .10–.99]; aOR for outdoor social distancing, 0.10 [95% CI, .03–.33]), giving some hints on the implications of mobility during the pandemic. It was consistent with the inference by Lemaitre et al. (22) who found a strong support for changes in R0 following the mobility decline before implementation of school closure, underlining the importance of behavior changes on the reductions in transmission. However, social distancing in different settings may have different impacts. The UK Scientific Advisory Group for Emergencies (SAGE) meeting report (23) suggested that stopping contact from different households would provide moderate impact by reducing R_t of 0.1-0.2 but the impact of physical distancing on outdoor gathering was minimal (R_t reduction <0.05) since good ventilation was usually observed.

Social distancing at level of community settings

School closure

School closure may have benefits during the pandemic, but the effectiveness was mixed when considering levels of closures and the unexpected link between school closure and school opening. Rivkees's (24) study in Florida of the U.S. found that closing schools resulted in a 40-55% reduction in average distance traveled compared with pre-outbreak levels. Moreover, Auger et al. (25) found that the primary and secondary school closure in the U.S. between March and May 2020 was associated with decreased COVID-19 incidence (adjusted relative change per week, −62%) and mortality (−58%). On the other hand, the SAGE report (23) suggested that closing secondary schools and further education could have more impact, even though a moderate R_t drop of 0.1 – 0.5 was associated with mass school closure, as mature students worked in daytime and linked up infection pathways between workplace and households. It was also proposed that states closing schools earlier, when cumulative incidence of COVID-19 was low, had the largest relative reduction in incidence and mortality, although there might be confounding effects from other interventions (26). Contrary to expected impacts of school closures, observational data in ECDC review suggested that re-opening schools had not been associated with significant increases of community transmission (12). In other studies (27, 28) that focused on the various measures used in educational and children care center settings after reopening, results showed low incidence rate in these settings. There was a decreasing trend of both the average outbreak numbers and the cases per outbreak by school measures and it might be partially due to the extensive measures. Meanwhile, the specific impact of reduction of face-to-face attendance in classrooms was not be assessed (29).

Workplace measures

Workplace measures include work-from-home arrangement, measures in working environment and the closure of businesses. The SAGE report (23) suggested a moderate impact of work-from-home measure, with a reduction of R_t between 0.2 and 0.4. Brauner et al. (18) estimated that a 29% R_t

reduction was likely to follow with closing most of non-essential businesses while closing high risk businesses, e.g. bars and restaurants would be associated with a Rt decline of 20%. Although there was limited empirical data on the impact of closure of businesses, reduced visits to nonessential businesses in the US was associated with a drop in Rt (20).

Public transport restriction

Public transport restriction refers to suspension/ limitation of intra-city or intercity public transportation. The SAGE report (23) suggested a low to moderate impact following the 5-mile travel restriction, especially when local outbreak was widespread. It might be because public transport crowding was low and mandated face-mask policy was already implemented. However, Islam's study (11) showed no difference in reduction with or without the suspension of public transportation. On the other hand, ECDC review showed contradictory results, with a modelling study indicating a strong association with reduction of Rt while other studies did not show any impact unless introduced with other NPIs such as social distancing and behavioral changes (12). Therefore, it is difficult to relate observed changes in transmission dynamics to this single measure of public transport restriction.

Social distancing at national/regional level

Combination of interventions - "partial" lockdown

While the studies mentioned above focused on the effect of single type of intervention, many studies showed the effect of a combination of interventions, which could be regarded as a "partial" lockdown. A study by Siedner et al. (26) in the U.S. found that the mean daily COVID-19 case growth rate fell by 0.9% per day, starting 4 days after implementation of the first statewide social distancing measures including cancellation of public events, travel restriction, school and workplace closures. In a study by

Randhawa et al.(30), the SARS-CoV-2 positivity rate in Seattle-area outpatient clinics and emergency departments declined from the peak range of 14.3-17.6% to 3.8-3.9% after statewide physical distancing measures, such as shutdown of bars/restaurants, implementation of social gathering limit and stay-home order. A drop of 2% in daily COVID-19-attributed mortality growth rate was also observed after 7 days the measures were implemented. Similarly, a study by Wan et al. (31) in Mainland China excluding Hubei (province of Wuhan) found that R_t has dropped sharply from 3.34 on 20 January 2020 to 0.89 on 31 January 2020 after implementing integrated control strategies. In Du's study (32) of 58 cities in China, also with a remarkable Rt drop, at 54.3%, demonstrating the effectiveness after the implementation of multiple types of interventions.

Full lockdown

Indeed, a full lockdown can be viewed as a combination of all measures. Islam et al. (11) reported a combination of 4 measures, including restrictions on mass gatherings, school closures, workplace closures, and lockdowns in 32 countries, were associated with decreasing incidence of COVID-19 (pooled incident rate ratio, IRR 0.87, 0.84 to 0.91). Similar declining incidence was also observed when public transport closure was added (pooled IRR 0.85, 0.82 to 0.88; n=72 countries). Other than incidence drop, bed occupancy could be also benefited from lockdown measures. In Lino's study (5), before the lockdown, the bed occupancy rates for referred COVID-19 cases in a tertiary hospital in Fortaleza of Brazil were over 100% in the beginning of May and reached nearly 140% after 10 days. The rates decreased to below 100% and 85% at 14 and 23 days respectively after the lockdown.

More evidence showed the effect of lockdown by various indicators. Zhang et al. (33) found that an average daily number of contacts per survey participant significantly dropped from 14.6 to 2 and 18.8 to 2.3 in Wuhan and Shanghai respectively during the lockdown period, consistent with the respective

trends of mobility data declining at 86.9% and 74.5%. Pan et al. (34) analyzed data from Wuhan and found that the R_t gradually reduced from larger than 3 in January 2020 to less than 1 in February 2020 and fell further to less than 0.3 in March 2020 after the city lockdown. Lim et al. (35) studied 9 Southeast Asian countries and found a large variation in social distancing policies across countries, leading to marked differences in the reduction in R_t, with the biggest decrease in Malaysia from 3.68 to 1.53 and the smallest decrease in Laos from 1.55 to 1.20. Similarly, a brief report of Rivkees et al. (24) showed that the stay-at- home order in Florida of the U.S., after the first month of implementation, resulted in a 74% to 82% reduction in person-to-person encounters, 55% in visits to non-essential venues and 45% in overall distance traveled. After two months of implementing stay-at-home order, the average distance traveled within the state was also found to decrease by 25-40%. Further, a modelling study of Brauner et al. (18) gathering data of 41 countries using NPIs estimated that stay-at-home orders (with exemptions) reduced the mean percentage of R_t by 10%. Moreover, in SAGE report (23), it suggested that the country lockdown was very impactful and could reduce R_t from 2.7 to 0.6 while 2-3 week short stay-at-home order had moderate impact in reducing R_t to below 1. As with all other measures, the earlier the stay-at-home order was implemented, the higher the impact.

Implementation points of time and impact on the pandemic curve

Nearly all findings found that a timely implementation of measures could reduce the transmission risk significantly. The relationships between the timing and the change rates of daily confirmed-cases were analyzed with a time-series. Marschner et al. (36) used Australia data to back-project that there was a fivefold increase in total infections if social distancing measures were delayed by one week. Consistently, in Du's study (32), a 1-day delay in implementing the 1st intervention was expected to prolong an outbreak by 2.41 days. However, earlier lockdown, simulated by Islam et al. (11), showed a larger reduction in COVID-19 incidence compared with a delayed one after other social distancing

interventions were initiated. Thanks to another empirical study based on the Oxford COVID-19 Government Response Tracker (37), some ideas can be grasped when deciding how to implement a measure earlier. It tracked Rt temporally for two weeks following the 100th reported case in 140 countries and observed the median timing among them, finding that lockdown measures and travel bans were considered early if they were implemented around two weeks before the 100th case and a week before detecting the first case respectively (37).

In addition, social distancing measures had a progressive control impact on the growth rates of daily confirmed cases, with Courtemanche et al. (38) showing reductions of 5.4%, 6.8%, 8.2% and 9.1% after 1-5 days, 6-10 days, 11-15 days, 16-20 days, respectively following the roll-out of the measures. The timing effect was further illustrated by Thu et al. (39) that social distancing interventions took 1-4 weeks to have an effect on the decline in number of infected cases among the 10-studied countries. For those countries with higher growth rates at the beginning may have more difficulties in controlling the transmission, and vice versa for those countries with initial lower growth rates. For example, China, Iran and Turkey, promulgating the most stringent level of social distancing measures, with initial infection growth rates apparently lower at around 60-70%, had the highest decline rates at 71%, 51.8% and 50.8% respectively while the U.S. and the U.K., having the highest initial growth rates (99.9%), experienced significantly lower decline rates of 14.8% and 25.9% respectively. The result suggested that social distancing measures could be more effective when being introduced earlier under situations with low growth rates.

Discussion

This scoping review covered a board range of social distancing interventions and outcome indicators. A comparison of the key findings of different levels of measures is shown in Table 3. Outcomes were

mainly indicated by changes in Rt, incidence and mortality, along with indirect indicators such as daily contact frequency and travel distance. Based on changes in Rt, incidence and mortality, there was adequate empirical evidence for the effect of social distancing at individual level, and for partial or full lockdown at community level. However, the evidence was moderate and inconsistent for school closure, and limited for workplace/business closures as a single type of intervention. There was no evidence for the separate effect of public transport restriction.

(Insert Table 3 here)

Many studies showed the combined effects of different social distancing interventions which were usually implemented as a package with 3-5 measures. Observed impact by an individual measure was scarcely reported or only demonstrated with modelling. For example, Islam et al. (11) reported that among 149 countries being studied, 118 countries covered 5 measures while 29 countries used 3 to 4 interventions, with only 1 country introducing 2 measures and the remaining 1 country using a single measure. In addition, even though the lockdown, in this review, was shown with the highest reduction in R_t, it had indeed been used along with multiple measures.

Apart from types of interventions, relationship between implementation time points and effect were investigated. Lam et al. (40); observed an early public health measure promulgation was able to contain the epidemic in Hong Kong, without initiating extreme measures such as a city-wide lockdown. Other studies suggested that the effect time variation might be due to the different times and levels of promulgating the social distancing measures, making the effectiveness apparently different (39). It could be demonstrated through the comparison between countries showing that the stronger the level of social distancing, the faster it took to reduce the number of daily confirmed cases (39). Furthermore, high initial infection incidence due to late implementation of measures would reduce the effectiveness

of measures (39). All these results indicated a need of rapid response and stringent measures to win the battle.

Contextual factors

In addition to the types, level and timing of social distancing measures highlighted in this review, the effectiveness of measures might also be affected by the contextual factors such as compliance, social belief and cultural factors. Low public compliance may be a key explanation that interventions showed no sign of flattening its curve. The compliance issue was further supported by Cruz's study (41) examining that the social distancing index (SDI), a social distancing adoption index used by the Brazilian government, larger than 55% was needed to reduce the daily death number. Moreover, social belief such as awareness of disease information might cultivate a sense of self-imposed initiation of handwashing, wearing protectives, purposely keeping a distance from people and reducing outdoor activities. Cultural factors may also have the influence on public gatherings, although it was too complicated for a quantitative evaluation regarding various timings, magnitudes and processes that have been happening in a region. Cultural factors were firstly studied in Huynh's study (42) illustrating that countries with higher Uncertainty Avoidance Index (UAI) predicted a smaller proportion of people gathering in public such as grocery and retail stores, pharmacy stores, recreation areas, public transport and workplaces whereas countries in the northern European such as Finland, Sweden, and Norway with lower uncertainty avoidance indices were unlikely to follow with social distancing measures. Further, Islam's study (11) observed greater case reduction associated with those countries with a higher GDP per capita, a higher proportion of population aged 65 years or above, and stronger preparedness for the pandemic in terms of country health security index. Therefore, the cultural determinants are likely to play an important role in controlling infection behaviour.

Knowledge gap for future research

Due to the heterogeneity of the outcomes adopted in the studies, it is difficult to render direct comparison of the changes in Rt and incidence. Consistent inclusion of these outcomes in studies of similar kinds may allow systematic review and meta-analysis in further studies.

Few studies have investigated the effect of closure of entertainment and eatery settings. The SAGE report (23) suggested that the closure of gyms, bars and restaurants were useful since the environmental risks linked to higher probability of touch surfaces, higher aerosol generation and breathing rates due to aerobic activities. Specifically, the risk in bars and pubs was likely to be higher than many other indoor settings due to close proximity of people, long exposure duration, no wearing of face coverings and talking loudly. Some venues were poorly ventilated, especially in winter. In addition, consumption of alcohol impacts on customers' behaviors. More empirical evidence focusing on the dynamic among the environment, customer behaviors and transmission risks would be beneficial.

Some researchers proposed strategies to be proven by empirical evidence. A circuit breaker, proposed in the SAGE report (23), referring to 2-3 week short-time lockdown, could put the epidemic curve back by about 28 days or more. Based on historical evidence from the 1918 flu pandemic, Correia et al. (45) argued that regions taking earlier and aggressive social distancing measures grew faster economically in the post-pandemic period although there were adverse effects on the economy during the pandemic period. Thus, predicting the recovery in an economy or a community based on the effectiveness of each intervention would be a matter of continuing concern.

Fatigue of pandemic prevention was seen everywhere during the course of COVID-19 pandemic which may exacerbate the peaks and resurgence following the relaxation of self-imposed measures and

undermine the public acceptance to the advice from authorities. Governments with good risk communication with the public, hinging on engagement, communication and feedback, would be essential to help individuals assess and reduce their own risks appropriately. Abel et al. (46) reported that social distancing might lead to depression and anxiety in some people, which in return have an impact on social stability. Psychological impacts were not only observed on patients, health care workers but also on the overall population. However, Kim et al. (47) suggested we should routinely provide psychological support instead of stopping social distancing measures. Future studies should explore the long term strategies for risk communication and risk analysis in specific settings to overcome public fatigue towards social distancing. Response measures should be proportional to the risk in different settings.

Our search period was till 30 September 2020. Vaccine was not yet ready by that time as most countries started to have mass vaccination programs after December 2020 (48). Reported number of cases per population was under 2.3% across countries. Including unreported asymptomatic cases, population immunity should still be insignificant that time. However, this study period may have an advantage to exclude the confounding effect of population immunity and mass vaccination to social distancing measures. Future studies may explore whether the effect of social distancing declines as the degree of population immunity increases.

Limitations

Although a lot of information about the measures taken was collected in government websites, measures being used in small localities or regional areas were not widely publicized or difficult to access, resulting in relevant studies being very limited. Moreover, there was a wide variation of testing accessibility and the criteria for who should be tested in different countries. Similarly, the points of

time of promulgation and severity level of interventions are different among countries. Therefore, the cumulative confirmed cases might not reflect the actual situation of population and were not accurate for comparisons. Using a time series analysis referencing to the date of death but not to the date of testing done will be under a possible variation of case reporting and might hinder the decision making process as long as 15-days delay in some countries. Another concern is that some studies used mobile device for people attendance changes in specific times and locations. The drawback was the unknown characteristics of those persons using mobile devices such as age and gender. The data only tracked mobile devices but not persons, who might have multiple devices (e.g., a phone and a tablet), or might not take their devices when they leave home. Hence, the results might not reflect the actual mobility patterns. Finally, our review excluded non-English literature. The English literature of COVID-19 might be biased towards countries with good research capacity and interests in publishing their findings for international audience.

Conclusions

Our review showed that the outcomes of social distancing measures were mainly measured by changes in R_t, incidence and mortality. There was empirical evidence for the effect of social distancing between individuals, and for partial or full lockdown. However, the evidence was moderate for the separate effect of school closure, and limited for workplace/business closures. There was no evidence for the separate effect of public transport restriction. In the community setting, there was more evidence on the combined effect of different social distancing interventions than for a single one. Apart from the effectiveness of the interventions, public compliance is another important issue. COVID-19 has been changing our lives and a new norm may emerge as we have to live with new variants of the virus, which may develop to a situation similar to that of the seasonal flu, where a total elimination is not the goal. Fatigue of preventive behaviors is on the top of the public health agenda. Community compliance with social distancing measures is related to the population's attitude to government policies, the

access/awareness of trustful sources of information, the initiations and maintenance to self-imposed measures. Therefore, risk communication and risk analysis continue to be the cornerstone of public health measures and need to be in conjunction with addressing the research gap for implementing effective measures which are targeted and proportionate to the risk in different settings.

Figure:

Figure 1. PRISMA flow diagram of literature search and selection

Contributors

EKY designed the study, applied for the grant and made major contributions to writing the manuscript. VCHC, EKY, KSS and CTH managed the review methodology. TSML, KSS and YSL conducted the review and data synthesis. TSML, KSS, EKY, CHKY and CTH wrote the first draft of the manuscript. All authors read, revised and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Ethics approval

Ethical approval was obtained from the Survey and Behavioural Research Ethics Committee of the Chinese University of Hong Kong (Ref no. SBRE-19-595).

Consent for publication

Not applicable.

Data sharing statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Table 1 Article characteristics (n=34)

		Count (%)
Countries/ cities by geographic region		
	Asia	13 (27.7)
	Australia & New Zealand	2 (4.3)
	Europe	12 (25.5)
	North America	14 (29.8)
	South America	3 (6.4)
	Global studies	3 (6.4)
Country economy[#]		
	High income	33 (63.5)
	Middle income	16 (30.8)
	Low income	3 (5.8)
Article type		
	Research article	38 (92.7)
	Review article	3 (7.3)

[#]Country economy level according to The World Bank's classification.

Table 2 Effectiveness and outcomes of social distancing measures

Article and Study Characteristics		Type of Social Distancing Measures						Effectiveness Indicators
Authors; article type; study period/ publication date; study design	**Country/ region; economy level**	**Social distancing between individuals**	**School measure / closure**	**Workplace measure / closure**	**Public transport restriction**	**Stay-at-home recommendation / ordinances**	**Others**	**Infectivity:** Rt, effective reduction number **Incidence:** incidence, incidence rate, attack rate, bed occupancy rate **Mortality:** Mortality or fatality rate **Effect time:** Action and effect duration, time of reaching peak **Attendance:** Attendance % of location, daily vehicles miles, daily contact frequency, mobility of leaving home, travel distance
Auger et al.(25) Research Article; 9/3/2020-7/5/2020; Population–based observational study of changes in incidence and mortality	The US; High		Statewide closure of primary and secondary schools					**(Incidence & mortality):** Primary and secondary school closure in the US between March and May 2020 was associated with decreased COVID-19 incidence (adjusted relative change per week, −62%) and mortality (−58%). States that closed schools earlier, when cumulative incidence of COVID-19 was low, had the largest relative reduction in incidence and mortality, although there might be confounding effects from other interventions.
Brauner et al. (18). Research Article; 22/1/2020-30/5/2020; Modelling study based on national case and death counts	Members of the EU countries; High	Limiting size of gathering		Closing most of non-essential businesses and high risk businesses, e.g. bars and restaurants				**(Infectivity):** 41 countries-pooled data showed Rt reduction of 36% when gatherings were limited to 10 people or below; 28% when 100 or below and 13% when 1,000 or below. A 29% R_t reduction came with closing most of non-essential businesses while 20% was found when closing high risk businesses, e.g. bars and restaurants.
Castaneda-Babarro et al. (49); Research article; 23/3/2020-1/4/2020; Cross-sectional survey on 800 general public for walking time	Spain; High	✓	Forced e-learning		Restricted travel	Country lockdown with stay-at-home measures		**(Attendance):** Self-reported walking time decreased by 58.2% during confinement.
Clipman et al. (21); Research article; 17–28/6/2020	Maryland, the US; High	✓						**(Incidence):** Multivariable analysis found that history of SARS-CoV-2 infection was significantly less common among those who always practiced social distancing (aOR for

Article and Study Characteristics		Type of Social Distancing Measures						Effectiveness Indicators
Authors; article type; study period/ publication date; study design	**Country/ region; economy level**	**Social distancing between individuals**	**School measure / closure**	**Workplace measure / closure**	**Public transport restriction**	**Stay-at-home recommendation / ordinances**	**Others**	**Infectivity:** Rt, effective reduction number **Incidence:** incidence, incidence rate, attack rate, bed occupancy rate **Mortality:** Mortality or fatality rate **Effect time:** Action and effect duration, time of reaching peak **Attendance:** Attendance % of location, daily vehicles miles, daily contact frequency, mobility of leaving home, travel distance
Cross-sectional survey on 1,030 general public for infection history and social distancing behaviors								indoor social distancing, 0.32 [95% CI, .10–.99]; aOR for outdoor social distancing, 0.10 [95% CI, .03–.33].
Cruz (41); Research article; 15/3 to 5/4/2020; Time series analysis of death counts	São Paulo City, Brazil; Middle	✓	Mandatory closure	Work-from-home and mandatory closure of non-essential businesses				**(Mortality):** Correlating daily death number with Social Distancing Index (SDI) was derived from government websites. SDI was between 52% and 56%, crossing the break-even point of death number (from 0.82 to -0.4). SDI larger than 55% is needed to reduce death number.
Courtemanche et al. (38) Research article; 1/3 – 27/4/2020; Analysis of growth rate of cases	The US; High	Ban on large social gathering with a limit of 50 people	Public school closure	Closing entertainment businesses		Shelter-in-place order (last policy)		**(Incidence):** Growth rate of daily confirmed cases reduced by 5.4% after 1-5 days, 6.8% after 6-10 days, 8.2% after 11-15 days, 9.1% after 16-20 days. The number of confirmed cases was 10 times greater without shelter-in-place order and 35 times greater without 4 types of social distancing measures.
Du et al.(32); Research article; 1/1 - 15/2/2020; Analysis of case data from online reports	58 cities of China; Middle	Ban on public gathering	✓	Closing shopping malls, restaurants and entertainment businesses	Suspension of intracity and intercity public transport	✓	Testing	**(Infectivity):** Rt declined by an average of 54.3% (+/- 17.6%) during the containment period. **(Effect time):** The mean time until successful containment was 21 days after the 1st reported case and 8 days following the initiation of interventions. During the period of containment, the R_t declined by an average of 54.3%. A delay of 1 day in implementing the 1st intervention is expected to prolong an outbreak by 2.41 days (95% CI 0.96–3.86)
Ehrhardt et al.(28); Research Letter;	Germany; High		50% class size				Enhance ventilation of	**(Incidence):** The infection for children aged 0-19 was 3.3% among all settings,

Article and Study Characteristics		Type of Social Distancing Measures						Effectiveness Indicators
Authors; article type; study period/ publication date; study design	**Country/ region; economy level**	**Social distancing between individuals**	**School measure / closure**	**Workplace measure / closure**	**Public transport restriction**	**Stay-at-home recommendation / ordinances**	**Others**	**Infectivity:** Rt, effective reduction number **Incidence:** incidence, incidence rate, attack rate, bed occupancy rate **Mortality:** Mortality or fatality rate **Effect time:** Action and effect duration, time of reaching peak **Attendance:** Attendance % of location, daily vehicles miles, daily contact frequency, mobility of leaving home, travel distance
25/5/20-25/8/20Analysis of COVID-19 cases aged 0–19 years who attended schools / childcare facilities			reduction, cancelling physical education lesson, physical distancing between children				rooms, policy for sick students to stay at home, facemask wearing, suspension of singing or use of wind instruments during music lesson, promoting hand hygiene, cough etiquette, cleaning of contact surfaces	suggesting child-to-child transmission in schools and childcare facilities was uncommon and not the primary cause of SARS-CoV-2 infection in children. It might be partially due to the infection control measures initiated after school/child-care-facility reopening.
Otte et al.(27); Research Letter; 28/1/20 – 31/8/20 Analysis of COVID-19 data on school outbreaks using national surveillance system	Germany; High		Opening school for specific grades, staggering timetables, alternating between remote and on-site teaching, restricting class size, keeping distance				Policies for sick students and staff to stay home, enhanced hand hygiene, wearing face masks, ventilation of rooms, respiratory etiquette	**(Incidence):** The average number of outbreaks and of cases per outbreak was smaller after reopening of schools (2.2 outbreaks/week and 4 cases/ outbreak) than before school closure (3.3 outbreaks/week and 6 cases/outbreak).

Article and Study Characteristics		Type of Social Distancing Measures						Effectiveness Indicators
Authors; article type; study period/ publication date; study design	**Country/ region; economy level**	**Social distancing between individuals**	**School measure / closure**	**Workplace measure / closure**	**Public transport restriction**	**Stay-at-home recommendation / ordinances**	**Others**	**Infectivity:** Rt, effective reduction number **Incidence:** incidence, incidence rate, attack rate, bed occupancy rate **Mortality:** Mortality or fatality rate **Effect time:** Action and effect duration, time of reaching peak **Attendance:** Attendance % of location, daily vehicles miles, daily contact frequency, mobility of leaving home, travel distance
			between students					
Huynh (42); Research article; 16/2 - 29/3/2020; Analysis of data from community mobility reports	58 countries; Low to high	Social distancing in: 1.retail and recreation 2.grocery and pharmacy 3.parks 4. transit stations 5.workplaces 6.residential areas						**(Attendance):** Attendance in percentage change of specific locations was reported. Countries with higher Uncertainty Avoidance Index (UAI) predicted lower proportion of people gathering in public such as retail and recreation, grocery and pharmacy, parks, transit stations, workplaces. Northern Europe (Finland, Sweden & Norway) with lower UAI was unlikely to commit to social distancing. The cultural determinants played an important role in controlling infection behaviour.
Islam et al. (11); Research article; 1/1– 30/5/2020; Natural experiment with interrupted time series analysis	149 countries; Low to High	Restriction of mass gathering and public events	School closure	Workplace closure	Public transport closure	Movement Lockdown		**(Incidence):** Overall, with any intervention, there was 13% reduction in incidence. Data suggested similar effectiveness when school closures, workplace closures, and restrictions on mass gatherings were in place. Earlier lockdown was associated with a larger reduction compared with a delay after other interventions were in place. A combination of 4 measures including restrictions on mass gatherings, school closures, workplace closures, and lockdowns in 32 countries was associated with decreasing incidence of COVID-19 (pooled incident rate ratio, IRR 0.87, 0.84 to 0.91).
Jarvis et al.; (50) Research article; 24/3-27/3/2020; Cohort survey on 1356 general public	The UK; High		School closure	Limiting time at work, having work closed and/or			Quarantine and isolation isolate	**(Attendance):** A 74% reduction in the average daily number of contacts was observed per participant (from 10.8 to 2.8). It was expected to be sufficient to reduce R0 from 2.6 before the lockdown to

Article and Study Characteristics		Type of Social Distancing Measures						Effectiveness Indicators
Authors; article type; study period/ publication date; study design	**Country/ region; economy level**	**Social distancing between individuals**	**School measure / closure**	**Workplace measure / closure**	**Public transport restriction**	**Stay-at-home recommendation / ordinances**	**Others**	**Infectivity:** Rt, effective reduction number **Incidence:** incidence, incidence rate, attack rate, bed occupancy rate **Mortality:** Mortality or fatality rate **Effect time:** Action and effect duration, time of reaching peak **Attendance:** Attendance % of location, daily vehicles miles, daily contact frequency, mobility of leaving home, travel distance
to report daily number of contacts				not visiting work				0.62 (95% confidence interval [CI] 0.37–0.89) after the lockdown, based on all types of contact and 0.37 (95% CI = 0.22–0.53) for physical contacts only.
Lemaitre et al.(22) Research Article; 24/2/2020-24/4/2020 Modelling study using data on hospitalizations and deaths	Switzerland; High	Ban on gathering	School closure	Closure of nonessential activities				**(Infectivity):** Strong support for changes in R0 following the mobility decline which happened before school closure (national-level mean probability across activities 0.70, cantonal range 0.55–0.99), High correlation between changes in R0 and changes in mobility was found, with the strongest associations shown in mobility to work, transit stations, retail and recreation, and residential (cross-correlations >0.9 in all cantons and nationally).
Juni et al.(51); Research article; 7– 13/3/2020; Prospective cohort study for incidence	144 countries; Low to High	Gathering of any size	✓	Closing restaurants, bars, or non-grocery stores				**(Incidence):** A rate ratio comparing the cumulative count of confirmed COVID-19 cases with that of previous week was reported. There was strong association of epidemic growth with mass gathering (RRR 0.65, 95% CI 0.53-0.79), school closure (RRR 0.63, 95% CI 0.57-0.78), business closure (RRR 0.62, 95% CI 0.45-0.85).
Khanna et al.(52); Review; Published on 10 April 2020;	China, HK, Singapore, South Korea, US, Italy, Spain, Iran and India; Middle to High				All transports in and out of Hubei were prohibited, with each citizen being allowed to go out for 30 minutes	3-week lockdown in Hubei	Quarantine of mild and asymptomatic cases for China Travelers	**(Infectivity):** China Rt reduced from 2.35 to 1.05 during the period of 16/1/2020–30/1/2020. **(Effect time):** China slowed the dispersal of infection to other cities by 2.91 days and increased the doubling time from 2 to 4 days. Other Chinese cities implementing preventive control measures earlier were reported 33.3% fewer cases in the first week

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					every two days			of their outbreaks compared with that of cities starting the control later.
Koh, et al. (37); Research report; 1/1/2020-28/5/2020 Analysis of effect of measures indicated by Rt	142 countries; Low to High	Cancellation of public events, restrictions on size of gatherings,	✓	Closure of workplace	Closures of public transport	Stay-at-home order	Restrictions on internal movements/ international travel	**(Infectivity):** Following the 100th case, it was found effective that complete travel bans and all forms of lockdown-type measures reduced average Rt over the 14 days. Stay-at-home recommendation and partial lockdowns were as effective as complete lockdowns when controlling the outbreaks. However, these measures were effective when it could be implemented early.
Macartney et al.(29); Research Article; 25/1/20-10/4/20. Analysis of confirmed cases in children and staff who attended schools or early childhood education and care settings	Australia; High		Reduced face-to-face attendance					**(Incidence):** Although the attack rate of secondary cases was 0.5% in schools, it was unable to assess the effect on transmission regarding hygiene or physical distancing used in educational settings
Lai et al. (44); Research article; 23/1 – 1/3/2020; Epidemiological study analyzing government information of the confirmed cases	Hong Kong; High		✓	Work from home			Border Control • Phases 1-3: (18/1-7/2) • Phase 4: (8-29/2) Mandatory quarantine for China travelers in phase 4	**(Infectivity):** Median Rt dropped from 1.07 to 0.75 with border control in phase 4 (8–29/2/2020).

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Lam et al.(40); Research article; 1/1 – 31/5/2020; Epidemiological study analyzing the changes in daily number of confirmed cases	Hong Kong; High	Cancellation of large scale events	School suspension from phases 1-4	Work from home for civil servants in phases 1 & 2			Entry restriction / quarantine for inbound travelers and asymptomatic testing	**(Mortality):** Case fatality ratio (0.4%) was much lower than global ones during the same period in WHO (6.1%).
Lasry et al.(53); Research article; 26/2 – 1/4/2020 Descriptive analysis using types and timing of mitigation interventions, cumulative number of reported cases, percentage change in confirmed cases and community mobility	4 US metropolitan areas: San Francisco, Seattle; New Orleans, and New York City; High	Ban on gathering of certain size	School closure	Restrictions on businesses		Stay-at-home orders (last policy)	States of Emergency (1st policy)	**(Attendance):** Mobility of leaving home was reported. In four localities, the percentage leaving home was close to 80% on February 26, and decreased to 42% in New York City, 47% in San Francisco, 52% in Seattle, and 61% in New Orleans on April 1. Mobility did not decline following the state of emergency alone but a combination of policies such as gathering restrictions or school closures and further decreased after stay-at-home orders. **(Incidence):** 3-day average percentage change in cumulative case count showed a decreasing trend by the last 2 weeks of March after a set of policies implemented.
Lino et al. (5); Research article; 1-31/5/2020 Observational study on bed occupation rates in a hospital following lockdown	Fortaleza (state capital city), Ceará, Brazil; Middle	✓		Suspension of commercial activities	Restricted daytime movements and interruption of intercity trips	City lockdown, night curfews		**(Incidence)** Bed occupancy rates in a tertiary hospital for referred COVID-19 cases were higher than 100% before the lockdown and reached nearly 140% 2 days after. The rate decreased to below 100% 14 days after the lockdown (viral incubation period), and dropped to about 85% 23 days after the lockdown onset.
Lim et al. (35); Research Article; 15/2/20-9/5/20.	9 Southeast countries including	No social gathering or	Close schools	Close of non-essential business,	No or limited capacity of public	Stay-at-home order, curfew from 10pm to 4am	Broader closure, mandatory	**(Incidence):** Average daily incidence declined gradually for all countries except the Philippines and Laos.

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Analysis of COVID-19 case counts from each Southeast Asian country collected from open web source	Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam; Middle to High	with people limit, 1-2 m physical distance in public place		work from home	transport, healthcare declaration forms required, no interstate transportation		masking in public place	**(Infectivity):** A large variation in Rt reduction, with the biggest decrease in Malaysia from 3.68 (95% CrI 3.47–3.91) to 1.53 (1.44–1.61) and the smallest decrease in Laos from 1.55 (1.04–2.08) to 1.20 (0.84–1.56).
Marschner (36); Research article; 25/1 – 8/5/2020 Back-projection study analyzing the probability distribution of the time between infection and diagnosis	Australia; High	Stage 2: limiting gathering of 2 people (26-31 March)		Stage 1: prohibited face-to-face meeting and entertainment activities (23 March)		Stage 3: prohibited leaving home (26-31 March)	Border control (20 March)	**(Effect time):** It was estimated that one week delay in control measures would lead to an almost fivefold increase in total infections but one week earlier control would reduce total infections of similar magnitude.
Munayco et al.(54); Research article; 23/1– 9/5/2020 Modelling study using the daily number of confirmed cases by date of symptoms onset	Peru; Middle	Ban on gathering of larger than 300 people on 12 March	School measure since 11/3				Closing country border, National Emergency Declaration on 16 March	**(Incidence):** Before the implementation of social distancing measures in Lima, the mean scaling of growth parameter, p, was estimated at 0.9 and the reproduction number at 2.3. School closures and other social distancing interventions slowed down the spread of the novel coronavirus, shifting the exponential growth trend to an approximately linear growth trend, with the scaling of growth parameter being reduced to 0.53.

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Pan et al.(34); Research article; 8/12/2019– 8/3/2020 Cohort study on data of 32 583 patients	China Wuhan; Middle	Social distancing			Traffic restriction	Cordons sanitaire	Universal symptom survey, home and centralized quarantine	**(Infectivity):** A reduction of Rt from larger than 3 in January to less than 1.0 on February 6 and then less than 0.3 in March after implementation of measures by different phases.
Patel P et al.(55); Research article; 30/1– 4/5/2020 Epidemiology study using the growth rate of confirmed cases	India; Middle	✓	✓	✓		Lockdown since 25 March	progressive travel restriction, health promotion and enhanced testing	**(infectivity):** A decline in Rt following NPIs implementation was observed, with a reduction from 2.51to 1.83 at the end of lockdown phase. Although the sub-exponential growth confirmed mitigation of epidemic, Rt larger than 1 still indicated ongoing disease transmission.
Randhawa et al.(30); Research letter; 1/3/20-16/4/20. Analysis of the positivity rates for SARS-CoV-2 in outpatient settings In Washington State and in emergency departments in Seattle	The US High	Statewide gathering limits		Statewide shut down of bars and restaurants		Washington State's stay-home order		**(Incidence):** The positivity rate was 17.6% in the outpatient clinics and 14.3% in emergency departments at the peak period and 3.8% and 9.8%, respectively, at the end of the analysis period.
Rivkees et al. (24); Brief report; 1/3/2020-31/5/2020	Florida, US High	✓	Closures of elementary schools, high schools, and universities for in-person classes	Restricted access to bars and restaurants, limited commerce to essential businesses	✓	Statewide stay-at-home order		**(Attendance)** Assessment of movement within the state using Google mobility and Unacast mobility analytics based on cell phone data showed that closing schools resulted in a 40-55% reduction in average distance traveled compared with pre-outbreak levels. The stay-at-home order was associated with a further reduction in

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								average distance traveled. During the period under stay-at-home order, the density of in-person encounters fell by 74-82%, visits to nonessential venues by 55%, and overall distance traveled by 45%. Average distance traveled within the state decreased by 25-40%.
Rubin et al. (20) Research Article; 25/2/2020- 23/4/ 2020 Cohort study using publicly de-identified data	The US; High	✓		Reduce visits to nonessential businesses				**(Infectivity):** In multivariable analysis, a 50% decline in visits to nonessential businesses was associated with a 45% decline in Rt (95%CI, 43%-49%). With a 70% decrease in visits to nonessential business, a fall below a threshold Rt of 1.0 was estimated in 202 counties (95.7%), including 17 of 21 counties (81.0%) in the top density decile and 52 of 53 counties (98.1%) in the lowest density quartile.
Saez et al. (56) Research report; 17/1/2020-5/4/2020 Time series analysis on the new daily cases	Spain High	Reducing travel, avoiding crowded places, using non-contact greetings	✓	Closure of workplaces, stadiums, cinemas, theatres and restaurants		✓	Quarantines, travel restrictions	After implementing the measures for one day, the variation rate of accumulated cases decreased daily by 3.059 percentage points on average (95% credibility interval: −5.371,−0.879) and the decline was greater when time passed and reached 5.11 percentage points on the last day of data collection. Despite not entering the decrease phase, the measures taken by the Spanish Government on March 14, 2020 managed to flatten the curve.
Siedner et al. (26); Research article; 10/3/2020- 26/5/2020 Longitudinal pretest–posttest	All 50 states of the US, High	Statewide social distancing measures with cancellation	✓	✓	Restrictions on internal movement and closure of state borders			**(Incidence)** The mean daily COVID-19 case growth rate dropped by 0.9% per day, starting 4 days after implementation of the first statewide social distancing measures. **(Mortality)** After implementing social distancing for 7 days, the COVID-19-

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comparison study of incidence and mortality		of public events						attributed mortality growth rate fell by 2.0% per day, although this decline was no longer statistically significant by 10 days.
Thu et al.(39); Research article; 11/1 - 2/5/2020 Time-series analysis based on daily cases	10 countries: the US, Spain, Italy, UK, France, Germany, Russia, Turkey, Iran and China; Middle to High	Cancellation of public events	✓	Work from home, cancellation of non-essential events	Domestic transportation restriction	By region and, by nationwide, by different phases	Entry restrictions to those from highly infected areas	**(Incidence):** Growth rates of daily confirmed cases in the UK and the US were the most severe, at 99.9%, followed by Spain at 99.2%, France at 96.2%, Italy at 95.4%, Germany at 85%, Russia at 72.2%, Turkey at 70.7% and Iran at 62.8%. Countries with high growth rate showed lower decline rate, showing longer time needed for those countries to control the epidemic by social distancing measures.
Vokó et al.(57); Research article; 1/2/2020-18/4/2020 Modelling study using daily new cases	28 European countries; High	Social distancing with public event ban	✓	✓	✓	✓		(Incidence) Incidence of new COVID-19 cases grew by 24% per day on average before the changepoint. From the changepoint observed, the growth rate was reduced to 0.9%, 0.3% increase, and to 0.7% and 1.7% decrease by increasing social distancing quartiles based on Social distance index (SDI) calculated based on Google Community Mobility Reports.
Wan et al.(31); Research article; 20/1/2020-3/3/2020 Modelling study using incidence data, with death and recovery cases	Mainland of China excluding Hubei; Middle	Social distancing and self-isolation			✓		Close contact tracing, body temperature measurement	**(Infectivity)** Rt has dropped sharply from 3.34 on 20 January 2020 to 0.89 on 31 January 2020, after integrated control strategies were implemented.
Weill et al. (19); Research article; 1/1/2020-21/4/2020 Event study design on behavior	The US; High	✓		business closures		Safer-at-home orders		**(Attendance):** Median distance traveled, retail and recreation, locations visited by a mobile device per day showed a sharp decrease in March after the implementation of social distancing measures, with the

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subsequent to state emergency orders								wealthier areas decreasing mobility more significantly than poorer areas. However, the trend shifted reversely after March regarding completely staying at home. People from wealthier areas shifted from the lowest before March to the most likely to completely stay at home after March, vice versa for those in poorer countries.
Wilasang et al.(58); Research article; From the date of 100 cases to 7/4/2020 Analysis on the number of daily new cases and the distribution of the serial interval	10 countries: Belgium, China, France, Germany, Iran, South Korea, Spain, Thailand, US and UK; Middle to High	✓				✓	Active case finding	**(Infectivity):** After 3-week control measures, only China and South Korea were successful in controlling the disease (Rt<1), while the others were unsuccessful. The study observed that countries with active case finding and prompt isolation could have a reduction in the reproduction number more rapidly.
Yehya et al.(59); Research article; 21/1-29/42020 Ecological study using secondary data to analyze relationship between timing of interventions and mortality	The US; High		School closure				Declaration of Emergency	**(Mortality):** Each day of delay of either intervention increased mortality risk by 5-6%.
Zhang et al.(33); Research article; 24 – 30/12/2019 as baseline	Wuhan and Shanghai; Middle		✓		✓			**(Attendance):** Daily contact frequency in Wuhan showed a reduction from 14.6 to 2.0 while Shanghai from 18.8 to 2.3. The trend was consistent with mobility data of an

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and 1-10/2/2020 as outbreak period Analysis on contact survey data reported by 1,193 study participants								86.9% and a 74.5% drop in Wuhan and Shanghai respectively.
Zhang et al. (43); Research article; 23/1– 9/5/2020 Analysis of the changes in incidence	Wuhan (China), Italy and the US; Middle to High	✓				Stay-at-home	Face mask	**(Incidence):** Daily new infection in New York decreased with a slope of 106 cases per day (decreasing rate at around 3%) after face mask-on policy, while US (excluding New York) increased with a slope of 70 cases per day (increasing rate at around 0.3%). The decreasing rate in the daily new infections in New York with face covering mandate was proportionately higher than that in the United States with only social distancing and stay-at-home order, illustrating the importance of face covering on stemming the virus spread. With mask-on policy, Italy showed an infection reduction by over 75,000 from April 6 to May 9.
58th SAGE meeting summary (23); Review;	The UK; High					Lockdown, short stay-at-home order		**(Infectivity):** Lockdown was very impactful and reduced Rt from 2.7 to 0.6. 2-3 week short stay-at-home order had moderate impact on reducing Rt to less than 1. Both showed high confidence correlation.
		Decreasing contact between households, closure of worship/						**(Infectivity):** Moderate impact was found by stopping contacts among different households, reducing Rt by around 0.1-0.2. Low to moderate impact was shown following closure of worship/ community centers, with a potential reduction in Rt up to

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		community centers, restriction on outdoor gatherings						0.1. Low impact came with the restriction on outdoor gatherings, with Rt being reduced to less than 0.05, considering the frailty of SARS-CoV2 under well-ventilated environment.
					Local 5-mile travel restriction, use of public transport restricted to key workers			**(Infectivity):** The impact of 5-mile travel restriction was considered as low to moderate, with limited benefit especially when local outbreak was widespread. Restricted use of public transport to key workers might have low impact due to low level of crowding, mandated face-mask policy and inconclusive evidence of the transmission risk in public transport.
			Mass / reactive school closure, closure of class with infection, alterative school schedules with half class sizes, closure of further/ high education or childcare					**(Infectivity):** Moderate impact of closing all schools was found, with a reduction in Rt of 0.2~0.5 while closing secondary schools was considered to be more effective, with a Rt drop of 0.35. Reactive school closure might have a moderate impact on the reduction in Rt of 0.12 ~ 0.45 whereas low to moderate impact was estimated for reactive closure of class with infection. Alternative school schedules with reduced class size were suggested to have moderate to low impact. Closure of further / higher education associated with moderate impact while closure of childcare might have low to moderate impact.
				Work from home, alternate work, closure				**(Infectivity):** Moderate impact of work from home was evaluated with a Rt reduction of 0.2-0.4 if all people followed while low to

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				of bars/ pubs/ cafes/ restaurants, closure of gym/ leisure centers, non-essential retail, personal services, adherence to "COVID security" arrangement in workplaces				moderate impact with a Rt drop up to 0.1 was estimated for alternate work. Moderate impact with potential reduction in Rt of 0.1-0.2 was predicted for the closure of bars/pub/restaurants. Closure of gym/ leisure centres associated with low to moderate impact, with potential reduction in Rt of up to 0.1. Impact of closure of non-essential retail and personal services was estimated to be limited. Adherence to "COVID security" in workplaces such as improved hand/ surface hygiene and added barrier setting was also considered as low impact.
ECDC (12); Review; Published on 24 Sept 2020	Members of the EU countries; High					Stay-at-home		**(Infectivity):** Rt reduced by 18% (ranging from 4-31%).
		Physical distance between 1-2m						**(Infectivity):** Physical distancing of 1 metre or more was linked to an approximately five-fold reduction of the transmission risk, with the protective effect being doubled for every extra metre added.
					Domestic travel restrictions: a cordon sanitaire or public transportation closure			**(Infectivity):** There were contradictory results on Rt among the studies. Modelling showed strong association while other studies showed no impact unless other NPI was put in place, e.g. physical distancing. It was difficult to relate observed changes in transmission dynamics to a single measure.
			School closure					**(Incidence):** Observational data suggested that reopening schools has not been associated with significant increases in community transmission.

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				Work from home, flexible working time and social distancing measures, closure of non-essential businesses				**(Infectivity):** There was a 40% Rt reduction by closing most of non-essential businesses while 31% by closing high risk businesses, e.g. restaurant/ bars/ nightclub/ cinemas/ gym.

Table 3 Comparison of the major outcomes of different types/levels of social distancing

	Social distancing between individuals	School closure	Workplace measures	Public transport restriction	"Partial" lockdown	Full lockdown
Relative frequency and consistency of evidence#	Adequate	Moderate	Limited	No	Adequate	Adequate
(Infectivity): Rt, effective reduction number	Physical distancing of 1 meter or more could reduce the transmission risk by 5 times and the protective impact was double for every extra meter (17). Estimated R_t reduced by 36%, 28% and 12% when gatherings were limited to 10, 100 and 1,000 people respectively (18).		Estimated 29% R_t reduction by closing most of non-essential businesses while 20% by closing high risk businesses (18). In the US, a 50% decline in visits to nonessential businesses was associated with a 45% decline in Rt [95%CI, 43%-49%] (20).	No difference in reduction in R_t (11).	In Mainland China excluding Hubei (province of Wuhan), R_t dropped from 3.34 to 0.89 (31). In 58 cities of China, R_t dropped by 54.3% (32).	From data of 41 countries, estimated R_t reduced by 10% by stay-at-home orders (−2%–22%) (18). UK estimation suggested that country lockdown could reduce R_t from 2.7 to 0.6 while 2-3 week short stay-at-home order had moderate impact by reducing R_t to below 1 (23). China R_t reduced from 2.35 to 1.05 during the lockdown (52).
(Incidence): Infection incidence/ ratio of incidence rate ratio/ attack rate/ bed occupancy rate	In the US, COVID-19 infection was less likely among the public who always practiced social distancing (aOR for indoor social distancing, 0.32 [95% CI, .10–.99]; aOR for outdoor social distancing, 0.10 [95% CI, .03–.33] (21).	In the US, school closure decreased COVID-19 incidence (adjusted relative change per week, −62%) (25). Observational data from a number of the EU countries suggested that re-opening of schools was not associated with increase of			In the US, mean daily COVID-19 case growth rate decreased by 0.9% per day four days after lockdown (26).	Data from 32 countries showed decreased incidence of COVID-19 (pooled incident rate ratio, IRR 0.87, 0.84 to 0.91) (11). Growth rate of daily confirmed cases reduced by 5.4% after 1-5 days, 6.8% after 6-10 days, 8.2% after 11-15 days, 9.1% after 16-20 days (38).

		community transmission (12).				
(Mortality): Mortality/ Fatality rate		In the US, school closure decreased COVID-19 related mortality (−58%) (25).			In the US, COVID-19-attributed mortality growth rate decreased by 2% per day seven days after lockdown (26).	
(Effect time): Action and Effect duration / Time of Reaching peak					In 58 cities of China, mean time until successful containment was 8 days (32).	
(Attendance): Attendance % of location/ daily vehicles miles/ daily contact frequency/ Mobility of leaving home/ distance travel		In Florida, the US found that closing of schools resulted in a 40-55% reduction in average distance traveled (24).			In Spain, self-reported walking time decreased by 58.2% (49).	In Wuhan and Shanghai, the average daily number of contacts dropped from 14.6 to 2 and 18.8 to 2.3 respectively during lockdown. Mobility dropped 86.9% and 74.5% in respective areas (33). Stay-at- home order in Florida of the US resulted in a reduction of in-person encounters by 74-82%, visits to nonessential venues by 55%, and overall distance traveled by 45% (24).

Relative frequency and consistency of evidence based on the studies reviewed, without risk of bias assessment

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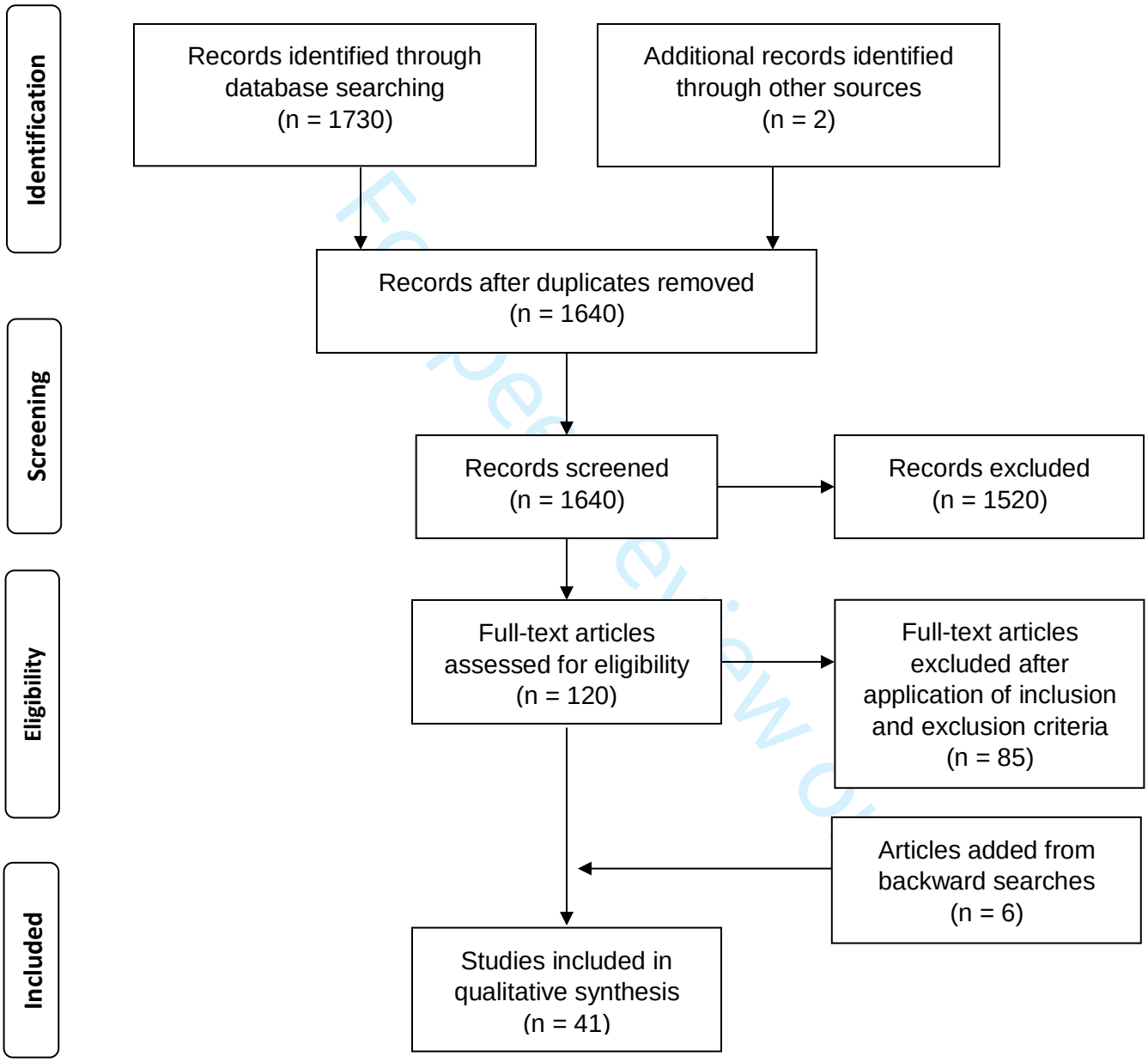
Figure 1. PRISMA flow diagram of literature search and selection



Databases and search period:
7 databases were selected and searched through Ovid platform.

AMED (Allied and Complementary Medicine) 1985 to September 2020**, Embase** 1910 to Present**, Global Health** 1973 to 2020 Week 40**, Ovid MEDLINE(R)** 1946 to September 30, 2020**, Ovid Nursing Database** 1946 to September Week 4 2020**, APA PsycInfo** 1806 to September Week 4 2020**, Social Work Abstracts** 1968 to September 2020

Search terms:
Sensitive search was conducted using these syntax, which included a higher number of articles (compared with specific search). Duplicated articles were removed after the searches.

"COVID*".m_titl. AND social distan*.ab.
"COVID*".m_titl. AND physical distan*.ab
"SARS-CoV-2*".m_titl. AND (social distan* or physical distan*).ab.

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	4-5
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	5
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Click here to enter text.
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	6
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	6
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	6
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	6-7
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	7
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	8
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	Click here to enter text.

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	7
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	7
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	8-13, 24-35
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	Click here to enter text.
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	24-35
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	8-13, 36-37
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	13-14
Limitations	20	Discuss the limitations of the scoping review process.	18
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	19
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	20

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.
* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.
† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).
‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.
§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850.

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Effectiveness of different types and levels of social distancing measures: a scoping review of global evidence from earlier stage of COVID-19 pandemic

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Effectiveness of different types and levels of social distancing measures: a scoping review of global evidence from earlier stage of COVID-19 pandemic

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Abstract

Objective: Social distancing is one of the main non-pharmaceutical interventions used in the control of the COVID-19 pandemic. This scoping review aims to synthesize research findings on the effectiveness of different types and levels of social distancing measures in the earlier stage of COVID-19 pandemic without the confounding effect of mass vaccination.

Design: Scoping review.

Data sources: MEDLINE, Embase, Global Health and four other databases were searched for eligible studies on social distancing for COVID-19 published from inception of the databases to 30 September 2020.

Study selection and data extraction: Effectiveness studies on social distancing between individuals, school closures, workplace/business closures, public transport restrictions and partial/full lockdown were included. Non-English articles, studies in healthcare settings or not based on empirical data were excluded.

Results: After screening 1638 abstracts and 8 additional articles from other sources, 41 studies were included for synthesis of findings. The review found that the outcomes of social distancing measures were mainly indicated by changes in R_t, incidence and mortality, along with indirect indicators such as daily contact frequency and travel distance. There was adequate empirical evidence for the effect of social distancing at the individual level, and for partial or full lockdown at the community level. However, at the level of social settings, the evidence was moderate for school closure, and was limited for workplace/business closures as single targeted interventions. There was no evidence for a separate effect of public transport restriction.

Conclusions: In the community setting, there was stronger evidence on the combined effect of different social distancing interventions than for a single intervention. As fatigue of preventive behaviors is an issue in public health agenda, future studies should analyze the risks in specific settings such as eateries and entertainment to implement and evaluate measures which are proportionate to the risk.

Keywords: COVID-19, effectiveness, incidence, scoping review, social distancing

Strengths and limitations of this study

- First scoping review to synthesize findings on the effectiveness of social distancing measures for COVID-19 at individual, community and national levels and social settings assessed by different outcome parameters.
- This review analyses the level of evidence for different types and levels of social distancing measures.
- Findings in varied outcome parameters could not be compared directly.
- Non-English literature was excluded from this review.

Introduction

Social distancing is one of the main non-pharmaceutical interventions (NPIs) to control the outbreak of COVID-19 worldwide. Social distancing, also known as physical distancing, is based on the premise that the rate of transmission of infectious diseases will decrease if people in communities stay at home from work or school, avoid large gatherings and refrain from having physical contact with each other. World Health Organization (WHO) guidelines describe social distancing measures at the individual level (e.g. keeping at least one meter from each other) and the community level including stay-at-home recommendation/ordinances and measures in specific socio-economic settings (e.g. workplace, schools, eateries, entertainment and parties) (1, 2). At the national or regional levels, lockdown (also called "community quarantine" to restrict movement of population groups) may be imposed as an extreme form of social distancing (3, 4), where it can be total or partial lockdown to restrict key socio-economic activities (5).

Despite the fact that social distancing measures have become a crucial strategy globally to mitigate COVID-19 pandemic, the evidence for their effectiveness is just slowly accruing. Earlier studies applied mathematical modelling to predict effectiveness of social distancing measures (6-9). Recent studies evaluated the outcomes retrospectively using empirical data and reported the outcomes within specific parameters. A study which analyzed data from 149 countries suggested that implementation of different social distancing interventions was associated with an overall reduction in COVID-19 incidence of 13% (IRR 0.87, 95% CI: 0.85 - 0.89) (10). It concluded that data from 11 countries indicated similar overall effectiveness (pooled IRR 0.85, 0.81 to 0.89) when school closures, workplace closures, and restrictions on mass gatherings were in place (10). The European Centre for Disease Prevention and Control (ECDC) also estimated the effectiveness of different types of social distancing in Europe. While most were based on prediction modelling, some retrospective analyses showed that lockdown reduced R_t from around 2.7 to 0.6 in the UK (11). Given different types,

variations and combinations of social distancing measures were implemented at different levels in different jurisdictions and pandemic contexts, it is important to study what parameters and methods were used and what outcomes were measured in various research studies. This is critical in a protracted pandemic after continuing restrictions to individual movement and socio-economic life, which have led to fatigue in preventive behaviors. In this context, targeted measures which have been evaluated to be proportionate to the risks should motivate continuing preventive behaviors.

This study aims to synthesize research findings on the effectiveness of different types and levels of social distancing measures during earlier stage of the COVID-19 pandemic. The study was conducted as a scoping review to include a broad range of outcome parameters and study designs. This enables a better understanding of the effectiveness of the spectrum of social distancing measures in controlling the COVID-19 pandemic.

Methods

The scoping review method was applied to include a range of parameters relating to effectiveness of social distancing measures during the COVID-19 pandemic. In contrast to a systematic review which answers a specific and narrow question, a scoping review aims to explore a set of emerging and diverse themes to synthesize the current evidence, clarify conceptual parameters and identify gaps for further research (12-14).

Eligibility criteria

Inclusion criteria for this review were studies that described: 1) effectiveness or outcomes of social distancing measures targeting the general public; 2) social distancing measures including those between individuals; targeted measures including closures of schools, workplaces, restaurants, bars

and other social settings; stay-at-home recommendation/ ordinances, community quarantine and lockdown; and 3) quantitative research, secondary data analysis, modelling studies based on empirical data, and review articles.

Exclusion criteria were: 1) qualitative studies, commentaries, mini-reviews without search strategies, editorials, conference presentations, dissertations, and book chapters); 2) non-English articles; 3) studies in healthcare settings, such as those on healthcare workers, hospital patients and elderly nursing homes; 4) studies on the impact of social distancing measures on non-COVID-19 disease management and psychosocial health of the public; and 5) hypothetical/stimulation models predicting future trends of incidence.

Search strategies and study selection

Seven electronic databases including AMED, Embase, Global Health, MEDLINE, Ovid Nursing Database, APA PsycInfo, Social Work Abstracts were searched by an experienced team member in scoping and systematic reviews. The search period was from the inception of the databases to 30 September 2020. To enhance sensitivity, syntax of *"COVID*".m_titl. AND social distan*.ab* and *"COVID*".m_titl. AND physical distan*.ab* were used as search strategies to cover both terms of social distancing and physical distancing. Additional syntax of *"SARS-CoV-2*".m_titl. and (social distan* or physical distan*).ab.* were used to search for articles using the keyword 'SARS-CoV-2'. Details are shown in the supplementary file. Furthermore, backward searches from the reference lists of the articles were conducted to locate additional articles and reports. The search and selection process followed the Joanna Briggs Institute Methods Manual for scoping reviews, and the reporting was guided by PRISMA Extension for Scoping Reviews (PRISMA-ScR)(15). Two reviewers independently screened the titles and abstracts to assess their eligibility. Full texts of potential citations were retrieved for detailed examination. Selection discrepancies were settled through discussions

between these two reviewers. Any outstanding disagreements were resolved by consulting the third member. We did not conduct risk of bias assessment, which is consistent with recommendations from the Joanna Briggs Institute Scoping Review Methods Manual and PRISMA-ScR (15), as different from a systematic review, a scoping review aims to provide an overview of the existing evidence comprehensively, regardless of risk of bias of included studies (15).

Data extraction and synthesis

For each study included, texts under the headings of 'results' or 'findings' were extracted and analyzed by two reviewers. The analysis was performed by one reviewer and verified by a second reviewer. The two reviewers reached consensus on the outcomes reported and their classification to corresponding types of social distancing and effectiveness indicators.

Patient and public involvement statement

It was not appropriate or possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research.

Results

Study selection and characteristics

We screened 1638 abstracts from our electronic search on the databases with 2 additional research reports identified from governmental websites. Of the 120 full texts retrieved for further assessment, 35 articles fulfilled our eligibility criteria. In addition, 6 relevant studies were identified from the reference lists of the articles through backward searches. Hence, in total, 41 studies were included in this review. Figure 1 presents results of the literature search and classification flow, and Table 1 provides detailed characteristics of the selected articles.

(Insert Figure 1 and Table 1 here)

There were 38 research studies and 3 reviews. Fourteen studies reported data from North America, another 13 from Asia, 12 from Europe, 3 from South America and 2 from Australia. There were also 3 global studies which reported data from over 50 countries in multiple regions. According to the classification by World Bank, 63.5% of the studies were from high-income countries/regions; 30.8% and 5.8% were from middle-income and low-income countries/regions respectively.

Table 2 summarizes the key findings based on the following effectiveness indicators: 1) Infectivity: R_t, effective reduction number; 2) Incidence: infection incidence, ratio of incidence rate, attack rate, or bed occupancy rate; 3) Mortality or fatality rate; 4) Effect time: action and effect duration, time of reaching peak; 5) Attendance percentage of location, daily vehicles miles, daily contact frequency, mobility of leaving home, or travel distance. A description of each type of intervention is also given. A tick "✓" is put if no detailed elaboration was provided in the reviewed articles.

(Insert Table 2 here)

Social distancing at individual level

Social distancing was usually achieved by prohibition of mass gathering in public areas and/ or maintaining certain physical distance between people. Most studies reported a positive relationship between the transmission risk and a certain level of social distancing. A meta-analysis including seven studies on COVID-19 concluded that physical distancing of 1 meter or more was effective in reducing the transmission risk by 5 times and the protective impact was double for every extra meter (16). Similarly, based on the chronological data on interventions in 41 countries between January and May 2020, Brauner et al. (17) estimated that R_t reduced by 36%, 28% and 12% when gatherings were

limited to 10, 100 and 1,000 people respectively. Furthermore, studies found how mobility changed according to different social distancing measures. A study by Weill et al. (18) in the U.S. found that median distance traveled, retail and recreation locations visited by a mobile device per day showed a sharp decrease in March 2020 after implementation of social distancing measures in the country, with the percentage of the population completely staying at home doubled. Similar results showed that a decline in visits to non-essential businesses following the implementation of social distancing was associated with a reduction in estimated R_t (19). In the analysis of 211 US counties, visits to nonessential businesses reduced by 50% and 70% contributed to a 45% decline in R_t and a drop of R_t to a threshold of 1.0 respectively, indicating that the larger the drop in nonessential business visits, the more significance in the reduction of a R_t (19). Another US study by Clipman et al. (20), in Maryland, found that a history of COVID-19 infection was significantly less likely among the public who always practised social distancing (adjusted OR for indoor social distancing, 0.32 [95% CI, .10–.99]; adjusted OR for outdoor social distancing, 0.10 [95% CI, .03–.33]), giving indications of the effect of mobility on the pandemic. It was consistent with the inference by Lemaitre et al. (21) who found a strong support for changes in R0 following the mobility decline before implementation of school closure, underlining the importance of behavior changes on the reductions in transmission. However, social distancing in different settings may have different impact. The UK Scientific Advisory Group for Emergencies (SAGE) meeting report (22) suggested that stopping contact from different households would provide moderate impact by reducing R_t of 0.1-0.2 but the impact of physical distancing on outdoor gathering was minimal (R_t reduction <0.05) since good ventilation was usually observed.

Social distancing at level of community settings

School closure

School closure may have benefits during the pandemic, but the effectiveness was mixed when considering levels of closures and the unexpected link between school closure and re-opening. Rivkees's (23) study in Florida of the U.S. found that closing schools resulted in a 40-55% reduction in average distance traveled compared with pre-outbreak levels. Moreover, Auger et al. (24) found that the primary and secondary school closure in the U.S. between March and May 2020 was associated with decreased COVID-19 incidence (adjusted relative change per week, −62%) and mortality (−58%). On the other hand, the SAGE report (22) suggested that closing secondary schools and further education could have greater impact, even though a moderate R_t drop of 0.1 – 0.5 was associated with mass school closure, as mature students worked in daytime and linked up infection pathways between workplace and households. It was also observed that states closing schools earlier, when cumulative incidence of COVID-19 was low, had the largest relative reduction in incidence and mortality, although there might be confounding effects from other interventions (25). Contrary to expected impacts of school closures, observational data in ECDC review suggested that re-opening schools had not been associated with significant increases of community transmission (11). In other studies (26, 27) that focused on the various measures used in educational and children care center settings after reopening, the results showed low incidence rate in these settings. There was a decreasing trend of both the average outbreak numbers and the cases per outbreak by school measures and might be partially due to the extensive measures. Meanwhile, the specific impact of reduction of face-to-face attendance in classrooms was not assessed (28).

Workplace measures

Workplace measures include work-from-home arrangement, measures in working environment and closure of businesses. The SAGE report (22) suggested a moderate impact of work-from-home measure, with a reduction of R_t between 0.2 and 0.4. Brauner et al. (17) estimated that a 29% R_t

reduction was likely to follow with closing most of non-essential businesses, while closing high risk businesses, e.g. bars and restaurants would be associated with a R_t decline of 20%. Although there was limited empirical data on the impact of closure of businesses, reduced visits to nonessential businesses in the U.S. was associated with a drop in R_t (19).

Public transport restriction

Public transport restriction refers to suspension/ limitation of intra-city or intercity public transportation. The SAGE report (22) suggested a low to moderate impact following the 5-mile travel restriction, especially when local outbreak was widespread. It might be because crowding in public transport was low and mandated face-mask policy had already been implemented. However, Islam's study (10) showed no difference in reduction with or without the suspension of public transportation. On the other hand, ECDC review showed contradictory results, with a modelling study indicating a strong association with reduction of Rt while other studies did not show any impact unless introduced with other NPIs such as social distancing and behavioral changes (11). Therefore, it is difficult to relate observed changes in transmission dynamics to this single measure of public transport restriction.

Social distancing at national/regional level

Combination of interventions - partial lockdown

While the studies mentioned above focused on the effect of single type of intervention, many studies showed the effect of a combination of interventions, which could be regarded as a partial lockdown. A study by Siedner et al. (25) in the U.S. found that the mean daily COVID-19 case growth rate fell by 0.9% per day, starting 4 days after implementation of the first statewide social distancing measures including cancellation of public events, travel restriction, school and workplace closures. In a study by

Randhawa et al.(29), the SARS-CoV-2 positivity rate in Seattle-area outpatient clinics and emergency departments declined from the peak range of 14.3-17.6% to 3.8-3.9% after statewide physical distancing measures, such as shutdown of bars/restaurants, implementation of social gathering limits and stay-home orders. A drop of 2% in daily COVID-19-attributed mortality growth rate was also observed 7 days after the measures were implemented. Similarly, a study by Wan et al. (30) in Mainland China excluding Hubei (province of Wuhan) found that R_t had dropped sharply from 3.34 on 20 January 2020 to 0.89 on 31 January 2020 after implementing integrated control strategies. In Du's study (31) of 58 cities in China, also with a remarkable R_t reduction, at 54.3%, demonstrating the effectiveness after the implementation of multiple types of interventions.

Full lockdown

A full lockdown can be viewed as a combination of all measures. Islam et al. (10) reported a combination of 4 measures, including restrictions on mass gatherings, school closures, workplace closures, and lockdowns in 32 countries, were associated with decreasing incidence of COVID-19 (pooled incident rate ratio, IRR 0.87, 0.84 to 0.91). Similar declining incidence was observed when public transport closure was added (pooled IRR 0.85, 0.82 to 0.88; n=72 countries). Other than incidence reduction, bed occupancy could also be benefited from lockdown measures. In Lino's study (4), before the lockdown, the bed occupancy rate for referred COVID-19 cases in a tertiary hospital in Fortaleza of Brazil was over 100% in the beginning of May and reached nearly 140% after 10 days. The rates decreased to below 100% and 85% at 14 and 23 days respectively after the lockdown.

There was more evidence showing the effect of lockdown with various indicators. Zhang et al. (32) found that an average daily number of contacts per survey participant significantly dropped from 14.6 to 2 and 18.8 to 2.3 in Wuhan and Shanghai respectively during the lockdown period, consistent with

the respective trends of mobility data declining at 86.9% and 74.5%. Pan et al. (33) analyzed data from Wuhan and found that the R_t gradually reduced from greater than 3 in January 2020 to less than 1 in February 2020 and fell further to less than 0.3 in March 2020 after the city lockdown. Lim et al. (34) studied 9 Southeast Asian countries found a large variation in social distancing policies across countries, leading to marked differences in the reduction in R_t, with the biggest decrease in Malaysia from 3.68 to 1.53 and the smallest decrease in Laos from 1.55 to 1.20. Similarly, a brief report from Rivkees et al. (23) showed that the stay-at- home order in Florida of the U.S., after the first month of implementation, resulted in a 74% to 82% reduction in person-to-person encounters, 55% in visits to non-essential venues and 45% in overall distance traveled. After two months of implementing stay-at-home order, the average distance traveled within the state was also found to decrease by 25-40%. Further, a modelling study of Brauner et al. (17) gathering data of 41 countries using NPIs estimated that stay-at-home orders (with exemptions) reduced the mean percentage of R_t by 10%. Moreover, in SAGE report (22), it was suggested that country lockdown was impactful and could reduce R_t from 2.7 to 0.6 while 2-3 week short stay-at-home order had moderate impact in reducing R_t to below 1. As with all other measures, the earlier the stay-at-home order was implemented, the higher the impact.

Implementation timing and impact on the pandemic curve

Nearly all findings found that a timely implementation of measures could reduce the transmission risk significantly. The relationships between the timing and the change in rates of daily confirmed-cases were analyzed with a time-series. Marschner et al. (35) used Australia data to back-project that there would be a fivefold increase in total infections if social distancing measures were delayed by one week. Consistently, in Du's study (31), a 1-day delay in implementing the 1st intervention was expected to prolong an outbreak by 2.41 days. However, earlier lockdown, simulated by Islam et al. (10), showed a larger reduction in COVID-19 incidence compared with a delayed one after other social distancing

interventions were initiated. Another empirical study based on the Oxford COVID-19 Government Response Tracker (36) tracked R_t temporally for two weeks following the 100th reported case in 140 countries and observed the median timing of implementation of measures across countries. The study found that lockdown measures and travel bans can be considered early if they were implemented around two weeks before the 100th case and a week before detecting the first case respectively (36).

In addition, social distancing measures had a progressive control impact on the growth rates of daily confirmed cases, with Courtemanche et al. (37) showing reductions of 5.4%, 6.8%, 8.2% and 9.1% after 1-5 days, 6-10 days, 11-15 days and 16-20 days, respectively following the roll-out of the measures. The timing effect was further illustrated by Thu et al. (38) that social distancing interventions took 1-4 weeks to have an effect on the decline in number of infected cases among the 10 countries studied. Countries with higher growth rates at the beginning might have greater difficulties in controlling the transmission, and vice versa for those countries with initial lower growth rates. For example, China, Iran and Turkey, promulgating the most stringent level of social distancing measures, with initial infection growth rates apparently lower at around 60-70%, had the highest decline rates at 71%, 51.8% and 50.8% respectively while the U.S. and the U.K., having the highest initial growth rates (99.9%), experienced significantly lower decline rates of 14.8% and 25.9% respectively. The result suggested that social distancing measures could be more effective when introduced earlier under situations with low growth rates.

Discussion

This scoping review covered a board range of social distancing interventions and outcome indicators. A comparison of the key findings of different levels of measures is shown in Table 3. Outcomes were mainly indicated by changes in R_t, incidence and mortality, along with indirect indicators such as daily

contact frequency and travel distance. Based on changes in R_t, incidence and mortality, there was adequate empirical evidence for the effect of social distancing at the individual level, and for partial or full lockdown at the community level. However, for targeted measures in social settings, the evidence was moderate and inconsistent for school closure, and limited for workplace/business closures. There was no evidence for the effect of public transport restriction alone.

(Insert Table 3 here)

Many studies reported the combined effects of different social distancing interventions which were usually implemented as a package of 3-5 measures. Observed impact of a single measure in a social setting was scarcely reported or only demonstrated with modelling. For example, Islam et al. (10) reported that among 149 countries studied, 118 countries implemented 5 measures while 29 countries used 3 to 4 interventions, with only one country introducing 2 measures and the remaining one implementing a single measure. In addition, even though the lockdown, in this review, was shown with the highest reduction in R_t, it had been implemented as multiple measures.

Apart from types of interventions, the relationship between implementation time points and the effect were also investigated. Lam et al. (39) observed an early public health measure promulgation was able to contain the epidemic in Hong Kong, without initiating extreme measures such as a city-wide lockdown. Other studies suggested that the effect time variation might be due to the different times and levels of promulgating the social distancing measures, making the effectiveness apparently different (38). It could be demonstrated through the comparison between countries that the stronger the level of social distancing, the faster it took to reduce the number of daily confirmed cases (38). Furthermore, high initial infection incidence due to late implementation of measures would reduce the effectiveness of measures (38). All these results indicated a need for a rapid response and stringent

measures to win the battle.

Contextual factors

In addition to the types, levels and timing of social distancing measures highlighted in this review, the effectiveness of measures was also affected by contextual factors such as compliance, social belief and cultural factors. Low public compliance may be a key explanation when interventions showed no sign of flattening of the epidemic curve. The compliance issue was further supported by Cruz's study (40) in examining the social distancing index (SDI), a social distancing adoption index used by the Brazilian government found that it needed to be larger than 55% to reduce the daily death number. Moreover, social belief such as awareness of disease information might cultivate a sense of self-imposed initiation of handwashing, wearing protectives, keeping a distance from people and reducing outdoor activities. Cultural factors may also have an influence on public gatherings, although it was too complicated for a quantitative evaluation of the timing, magnitudes and processes that were prevalent in a region. Cultural factors were studied in Huynh's study (41) illustrating that countries with higher Uncertainty Avoidance Index (UAI) predicted a smaller proportion of people gathering in public such as in grocery and retail stores, pharmacies stores, recreation areas, public transport and workplaces, whereas countries in the northern European such as Finland, Sweden, and Norway with lower uncertainty avoidance indices people were unlikely to follow social distancing measures. Further, Islam's study (10) observed greater case reduction associated with those countries with a higher GDP per capita, a higher proportion of population aged 65 years or above, and stronger preparedness for the pandemic measured by the country health security index. Therefore, cultural determinants are likely to play an important role in compliance with preventive behaviours.

Knowledge gap for future research

Due to the heterogeneity of the outcomes adopted in the studies, it is difficult to render direct comparison of the changes in R_t and incidence. Consistent inclusion of these outcomes in studies of similar kinds may allow systematic review and meta-analysis in further studies.

Few studies have investigated the effect of closure of entertainment and eatery settings. The SAGE report (22) suggested that closures of gyms, bars and restaurants were useful since there were environmental risks linked to higher probability of touch surfaces, higher aerosol generation and breathing rates due to aerobic activities. Specifically, the risk in bars and pubs was likely to be higher than many other indoor settings due to close proximity of people, long exposure duration, no wearing of face coverings and talking loudly. Some venues were poorly ventilated, especially in winter. In addition, consumption of alcohol impacts on customers' behaviors. More empirical evidence focusing on the dynamic interaction of the environment, customer behaviors and transmission risks would be beneficial.

Some researchers proposed strategies to be proven by empirical evidence. A circuit breaker, proposed in the SAGE report (22), referring to as a 2-3 week short-time lockdown, could put the epidemic curve back by about 28 days or more. Based on historical evidence from the 1918 flu pandemic, Correia et al. (42) argued that regions taking earlier and aggressive social distancing measures grew faster economically in the post-pandemic period although there were adverse effects on the economy during the pandemic. Thus, predicting the recovery in an economy or a community based on the effectiveness of each intervention would be a continuing concern.

Fatigue of pandemic prevention was seen everywhere during the course of COVID-19 pandemic which may exacerbate the peaks and resurgence following the relaxation of measures and undermine the

public acceptance to the advice from authorities. Governments with good risk communication with the public, hinging on engagement, communication and feedback, would be essential to help individuals assess and reduce their own risks appropriately. Abel et al. (43) reported that social distancing might lead to depression and anxiety in some people, which in turn would have an impact on social stability. Psychological impacts were not only observed on patients, health care workers but also on the overall population. However, Kim et al. (44) suggested we should routinely provide psychological support instead of stopping social distancing measures. Future studies should explore the longer-term strategies for risk communication and risk analysis in specific settings to minimise public fatigue towards social distancing. Response measures should be proportional to the risk in different settings.

Our search period was till 30 September 2020 when vaccine was not available. For mass vaccination programs which were implemented in most countries after December 2020 (45). The reported number of cases per population was under 2.3% across countries. Including unreported asymptomatic cases, population immunity should have still be insignificant during this period. However, this study period may have an advantage in excluding the confounding effect of population immunity and mass vaccination on the effects of social distancing measures. Future studies should explore whether the effect of social distancing declines as the degree of population immunity increases.

Limitations

Although a lot of information on the measures taken was collected from government websites, measures implemented in small localities or regional areas were not widely publicized or difficult to access, resulting in relevant studies being limited. Moreover, there was a wide variation of testing accessibility and for the criteria who should be tested, in different countries. Similarly, the points of time of promulgation and severity level of interventions were different among countries. Therefore,

the cumulative confirmed cases might not reflect the actual situation in the population and were not accurate for comparisons. Using a time series analysis referencing to the date of death but not to the date of testing might be under a possible variation of case reporting and might delay the reporting process for as long as 15-days. Another concern is that some studies used mobile device for imputing people attendance changes in specific times and locations. The drawback was the characteristics of those persons using mobile devices such as age and gender were unknown. The data only tracked mobile devices but not persons, who might have multiple devices (e.g., a phone and a tablet), or might not take their devices when they left home. Hence, the results might not reflect the actual mobility patterns. Finally, our review excluded non-English literature. The English literature of COVID-19 might be biased towards countries with good research capacity and interests in publishing their findings for an international audience.

Conclusions

Our review showed that the outcomes of social distancing measures were mainly measured by changes in R_t, incidence and mortality. There was empirical evidence for the effect of social distancing between individuals, and for partial or full lockdowns. However, the evidence was moderate for the separate effect of school closure and limited for workplace/business closures. There was no evidence for the separate effect of public transport restriction. In the community setting, there was more evidence of the combined effect of different social distancing interventions than for a single intervention. Apart from the effectiveness of the interventions, public compliance is another important issue. COVID-19 has been changing our lives and a new norm may emerge as we have to live with new variants of the virus, which may develop to a situation similar to that of the seasonal flu, where a total elimination is not the goal. Fatigue of preventive behaviors is on the top of the public health agenda. Community compliance with social distancing measures is related to the population's attitude to government policies, access/awareness of trustful sources of information, the initiations and maintenance to self-

imposed measures. Therefore, risk communication and risk analysis continue to be of cornerstone of public health measures and to address research gaps for implementing effective measures which are targeted and proportionate to the risk in different settings.

Figure:

Figure 1. PRISMA flow diagram of literature search and selection

Contributors

EKY designed the study, applied for the grant and made major contributions to writing the manuscript. VCHC, EKY, KSS and CTH managed the review methodology. TSML, KSS and YSL conducted the review and data synthesis. TSML, KSS, EKY, CHKY and CTH wrote the first draft of the manuscript. All authors read, revised and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Ethics approval

Ethical approval was obtained from the Survey and Behavioural Research Ethics Committee of the Chinese University of Hong Kong (Ref no. SBRE-19-595).

Consent for publication

Not applicable.

Data sharing statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Table 1 Article characteristics (n=41)

		Count (%)
Countries/ cities by geographic region		
	Asia	13 (27.7)
	Australia & New Zealand	2 (4.3)
	Europe	12 (25.5)
	North America	14 (29.8)
	South America	3 (6.4)
	Global studies	3 (6.4)
Country economy[#]		
	High income	33 (63.5)
	Middle income	16 (30.8)
	Low income	3 (5.8)
Article type		
	Research article	38 (92.7)
	Review article	3 (7.3)

[#]Country economy level according to The World Bank's classification.

Table 2 Effectiveness and outcomes of social distancing measures

Article and Study Characteristics		Type of Social Distancing Measures						Effectiveness Indicators
Authors; article type; study period/ publication date; study design	**Country/ region; economy level**	**Social distancing between individuals**	**School measure / closure**	**Workplace measure / closure**	**Public transport restriction**	**Stay-at-home recommendation / ordinances**	**Others**	**Infectivity:** R_t, effective reduction number **Incidence:** Incidence, incidence rate, attack rate, bed occupancy rate **Mortality:** Mortality or fatality rate **Effect time:** Action and effect duration, time of reaching peak **Attendance:** Attendance % of location, daily vehicles miles, daily contact frequency, mobility of leaving home, travel distance
Auger et al.(24) Research article; 9/3/2020-7/5/2020; Population–based observational study of changes in incidence and mortality	The US; High		Statewide closure of primary and secondary schools					**(Incidence & mortality):** Primary and secondary school closure in the US between March and May 2020 was associated with decreased COVID-19 incidence (adjusted relative change per week, −62%) and mortality (−58%). States that closed schools earlier, when cumulative incidence of COVID-19 was low, had the largest relative reduction in incidence and mortality, although there might be confounding effects from other interventions.
Brauner et al. (17). Research article; 22/1/2020-30/5/2020; Modelling study based on national case and death counts	Members of the EU countries; High	Limiting size of gathering		Closing most of non-essential businesses and high-risk businesses, e.g. bars and restaurants				**(Infectivity):** 41 countries-pooled data showed R_t reduction of 36% when gatherings were limited to 10 people or below; 28% when 100 or below and 13% when 1,000 or below. A 29% R_t reduction came with closing most of non-essential businesses while 20% was found when closing high risk businesses, e.g., bars and restaurants.
Castaneda-Babarro et al. (46); Research article; 23/3/2020-1/4/2020; Cross-sectional survey on 800 general public for walking time	Spain; High	✓	Forced e-learning		Restricted travel	Country lockdown with stay-at-home measures		**(Attendance):** Self-reported walking time decreased by 58.2% during confinement.
Clipman et al. (20); Research article; 17–28/6/2020	Maryland, the US; High	✓						**(Incidence):** Multivariable analysis found that history of SARS-CoV-2 infection was significantly less common among those who always practiced social distancing (aOR for

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Authors; article type; study period/ publication date; study design	**Country/ region; economy level**	**Social distancing between individuals**	**School measure / closure**	**Workplace measure / closure**	**Public transport restriction**	**Stay-at-home recommendation / ordinances**	**Others**	**Infectivity:** R_t, effective reduction number **Incidence:** Incidence, incidence rate, attack rate, bed occupancy rate **Mortality:** Mortality or fatality rate **Effect time:** Action and effect duration, time of reaching peak **Attendance:** Attendance % of location, daily vehicles miles, daily contact frequency, mobility of leaving home, travel distance
Cross-sectional survey on 1,030 general public for infection history and social distancing behaviors								indoor social distancing, 0.32 [95% CI, .10–.99]; aOR for outdoor social distancing, 0.10 [95% CI, .03–.33].
Cruz (40); Research article; 15/3 to 5/4/2020; Time series analysis of death counts	São Paulo City, Brazil; Middle	✓	Mandatory closure	Work-from-home and mandatory closure of non-essential businesses				**(Mortality):** Correlating daily death number with Social Distancing Index (SDI) was derived from government websites. SDI was between 52% and 56%, crossing the break-even point of death number (from 0.82 to -0.4). SDI larger than 55% is needed to reduce death number.
Courtemanche et al. (37) Research article; 1/3 – 27/4/2020; Analysis of growth rate of cases	The US; High	Ban on large social gathering with a limit of 50 people	Public school closure	Closing entertainment businesses		Shelter-in-place order (last policy)		**(Incidence):** Growth rate of daily confirmed cases reduced by 5.4% after 1-5 days, 6.8% after 6-10 days, 8.2% after 11-15 days, 9.1% after 16-20 days. The number of confirmed cases was 10 times greater without shelter-in-place order and 35 times greater without 4 types of social distancing measures.
Du et al.(31); Research article; 1/1 - 15/2/2020; Analysis of case data from online reports	58 cities of China; Middle	Ban on public gathering	✓	Closing shopping malls, restaurants and entertainment businesses	Suspension of intracity and intercity public transport	✓	Testing	**(Infectivity):** R_t declined by an average of 54.3% (+/- 17.6%) during the containment period. **(Effect time):** The mean time until successful containment was 21 days after the 1st reported case and 8 days following the initiation of interventions. During the period of containment, the R_t declined by an average of 54.3%. A delay of 1 day in implementing the 1st intervention is expected to prolong an outbreak by 2.41 days (95% CI 0.96–3.86)
Ehrhardt et al.(27); Research letter;	Germany; High		50% class size				Enhance ventilation of	**(Incidence):** The infection for children aged 0-19 was 3.3% among all settings,

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Authors; article type; study period/ publication date; study design	**Country/ region; economy level**	**Social distancing between individuals**	**School measure / closure**	**Workplace measure / closure**	**Public transport restriction**	**Stay-at-home recommendation / ordinances**	**Others**	**Infectivity:** R_t, effective reduction number **Incidence:** Incidence, incidence rate, attack rate, bed occupancy rate **Mortality:** Mortality or fatality rate **Effect time:** Action and effect duration, time of reaching peak **Attendance:** Attendance % of location, daily vehicles miles, daily contact frequency, mobility of leaving home, travel distance
25/5/20-25/8/20 Analysis of COVID-19 cases aged 0–19 years who attended schools / childcare facilities			reduction, cancelling physical education lesson, physical distancing between children				rooms, policy for sick students to stay at home, facemask wearing, suspension of singing or use of wind instruments during music lesson, promoting hand hygiene, cough etiquette, cleaning of contact surfaces	suggesting child-to-child transmission in schools and childcare facilities was uncommon and not the primary cause of SARS-CoV-2 infection in children. It might be partially due to the infection control measures initiated after school/child-care-facility reopening.
Otte et al.(26); Research letter; 28/1/20 – 31/8/20 Analysis of COVID-19 data on school outbreaks using national surveillance system	Germany; High		Opening school for specific grades, staggering timetables, alternating between remote and on-site teaching, restricting class size, keeping distance				Policies for sick students and staff to stay home, enhanced hand hygiene, wearing face masks, ventilation of rooms, respiratory etiquette	**(Incidence):** The average number of outbreaks and of cases per outbreak was smaller after reopening of schools (2.2 outbreaks/week and 4 cases/ outbreak) than before school closure (3.3 outbreaks/week and 6 cases/outbreak).

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			between students					
Huynh (41); Research article; 16/2 - 29/3/2020; Analysis of data from community mobility reports	58 countries; Low to high	Social distancing in: 1. retail and recreation 2. grocery and pharmacy 3.parks 4. transit stations 5. workplaces 6. residential areas						**(Attendance):** Attendance in percentage change of specific locations was reported. Countries with higher Uncertainty Avoidance Index (UAI) predicted lower proportion of people gathering in public such as retail and recreation, grocery and pharmacy, parks, transit stations, workplaces. Northern Europe (Finland, Sweden & Norway) with lower UAI was unlikely to commit to social distancing. The cultural determinants played an important role in controlling infection behaviour.
Islam et al. (10); Research article; 1/1– 30/5/2020; Natural experiment with interrupted time series analysis	149 countries; Low to High	Restriction of mass gathering and public events	School closure	Workplace closure	Public transport closure	Movement Lockdown		**(Incidence):** Overall, with any intervention, there was 13% reduction in incidence. Data suggested similar effectiveness when school closures, workplace closures, and restrictions on mass gatherings were in place. Earlier lockdown was associated with a larger reduction compared with a delay after other interventions were in place. A combination of 4 measures including restrictions on mass gatherings, school closures, workplace closures, and lockdowns in 32 countries was associated with decreasing incidence of COVID-19 (pooled incident rate ratio, IRR 0.87, 0.84 to 0.91).
Jarvis et al.; (47) Research article; 24/3-27/3/2020;	The UK; High		School closure	Limiting time at work, having work closed and/or			Quarantine and isolation isolate	**(Attendance):** A 74% reduction in the average daily number of contacts was observed per participant (from 10.8 to 2.8). It was expected to be sufficient to

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Cohort survey on 1356 general public to report daily number of contacts				not visiting work				reduce R0 from 2.6 before the lockdown to 0.62 (95% confidence interval [CI] 0.37–0.89) after the lockdown, based on all types of contact and 0.37 (95% CI = 0.22–0.53) for physical contacts only.
Lemaitre et al.(21) Research article; 24/2/2020-24/4/2020 Modelling study using data on hospitalizations and deaths	Switzerland; High	Ban on gathering	School closure	Closure of nonessential activities				**(Infectivity):** Strong support for changes in R_0 following the mobility decline which happened before school closure (national-level mean probability across activities 0.70, cantonal range 0.55–0.99), High correlation between changes in R_0 and changes in mobility were found, with the strongest associations shown in mobility to work, transit stations, retail and recreation, and residential (cross-correlations >0.9 in all cantons and nationally).
Juni et al.(48); Research article; 7– 13/3/2020; Prospective cohort study for incidence	144 countries; Low to High	Gathering of any size	✓	Closing restaurants, bars, or non-grocery stores				**(Incidence):** A rate ratio comparing the cumulative count of confirmed COVID-19 cases with that of previous week was reported. There was strong association of epidemic growth with mass gathering (RRR 0.65, 95% CI 0.53-0.79), school closure (RRR 0.63, 95% CI 0.57-0.78), business closure (RRR 0.62, 95% CI 0.45-0.85).
Khanna et al.(49); Review; Published on 10 April 2020;	China, HK, Singapore, South Korea, US, Italy, Spain, Iran and India; Middle to High				All transports in and out of Hubei were prohibited, with each citizen being allowed to go out for 30 minutes	3-week lockdown in Hubei	Quarantine of mild and asymptomatic cases for China Travelers	**(Infectivity):** China R_t reduced from 2.35 to 1.05 during the period of 16/1/2020–30/1/2020. **(Effect time):** China slowed the dispersal of infection to other cities by 2.91 days and increased the doubling time from 2 to 4 days. Other Chinese cities implementing preventive control measures earlier were

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					every two days			reported 33.3% fewer cases in the first week of their outbreaks compared with that of cities starting the control later.
Koh, et al. (36); Research report; 1/1/2020-28/5/2020 Analysis of effect of measures indicated by Rt	142 countries; Low to High	Cancellation of public events, restrictions on size of gatherings,	✓	Closure of workplace	Closures of public transport	Stay-at-home order	Restrictions on internal movements/ international travel	**(Infectivity):** Following the 100th case, it was found effective that complete travel bans and all forms of lockdown-type measures reduced average R_t over the 14 days. Stay-at-home recommendation and partial lockdowns were as effective as complete lockdowns when controlling the outbreaks. However, these measures were effective when it could be implemented early.
Macartney et al.(28); Research article; 25/1/20-10/4/20. Analysis of confirmed cases in children and staff who attended schools or early childhood education and care settings	Australia; High		Reduced face-to-face attendance					**(Incidence):** Although the attack rate of secondary cases was 0.5% in schools, it was unable to assess the effect on transmission regarding hygiene or physical distancing used in educational settings
Lai et al. (50); Research article; 23/1 – 1/3/2020; Epidemiological study analyzing government information of the confirmed cases	Hong Kong; High		✓	Work from home			Border Control • Phases 1-3: (18/1-7/2) • Phase 4: (8-29/2) Mandatory quarantine for China	**(Infectivity):** Median R_t dropped from 1.07 to 0.75 with border control in phase 4 (8–29/2/2020).

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							travelers in phase 4	
Lam et al.(39); Research article; 1/1 – 31/5/2020; Epidemiological study analyzing the changes in daily number of confirmed cases	Hong Kong; High	Cancellation of large-scale events	School suspension from phases 1-4	Work from home for civil servants in phases 1 & 2			Entry restriction / quarantine for inbound travelers and asymptomatic testing	**(Mortality):** Case fatality ratio (0.4%) was much lower than global ones during the same period in WHO (6.1%).
Lasry et al.(51); Research article; 26/2 – 1/4/2020 Descriptive analysis using types and timing of mitigation interventions, cumulative number of reported cases, percentage change in confirmed cases and community mobility	4 US metropolitan areas: San Francisco, Seattle; New Orleans, and New York City; High	Ban on gathering of certain size	School closure	Restrictions on businesses		Stay-at-home orders (last policy)	States of Emergency (1st policy)	**(Attendance):** Mobility of leaving home was reported. In four localities, the percentage leaving home was close to 80% on February 26, and decreased to 42% in New York City, 47% in San Francisco, 52% in Seattle, and 61% in New Orleans on April 1. Mobility did not decline following the state of emergency alone but a combination of policies such as gathering restrictions or school closures and further decreased after stay-at-home orders. **(Incidence):** 3-day average percentage change in cumulative case count showed a decreasing trend by the last 2 weeks of March after a set of policies implemented.
Lino et al. (4); Research article; 1-31/5/2020 Observational study on bed occupation rates in a hospital following lockdown	Fortaleza (state capital city), Ceará, Brazil; Middle	✓		Suspension of commercial activities	Restricted daytime movements and interruption of intercity trips	City lockdown, night curfews		**(Incidence)** Bed occupancy rates in a tertiary hospital for referred COVID-19 cases were higher than 100% before the lockdown and reached nearly 140% 2 days after. The rate decreased to below 100% 14 days after the lockdown (viral incubation period) and dropped to about 85% 23 days after the lockdown onset.

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Lim et al. (34); Research article; 15/2/20-9/5/20. Analysis of COVID-19 case counts from each Southeast Asian country collected from open web source	9 Southeast countries including Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand and Viet Nam; Middle to High	No social gathering or with people limit, 1-2 m physical distance in public place	Close schools	Close of non-essential business, work from home	No or limited capacity of public transport, healthcare declaration forms required, no interstate transportation	Stay-at-home order, curfew from 10pm to 4am	Broader closure, mandatory masking in public place	**(Incidence):** Average daily incidence declined gradually for all countries except the Philippines and Laos. **(Infectivity):** A large variation in R_t reduction, with the biggest decrease in Malaysia from 3.68 (95% CrI 3.47–3.91) to 1.53 (1.44–1.61) and the smallest decrease in Laos from 1.55 (1.04–2.08) to 1.20 (0.84–1.56).
Marschner (35); Research article; 25/1 – 8/5/2020 Back-projection study analyzing the probability distribution of the time between infection and diagnosis	Australia; High	Stage 2: limiting gathering of 2 people (26-31 March)		Stage 1: prohibited face-to-face meeting and entertainment activities (23 March)		Stage 3: prohibited leaving home (26-31 March)	Border control (20 March)	**(Effect time):** It was estimated that one week delay in control measures would lead to an almost fivefold increase in total infections but one week earlier control would reduce total infections of similar magnitude.
Munayco et al.(52); Research article; 23/1– 9/5/2020 Modelling study using the daily number of confirmed cases by	Peru; Middle	Ban on gathering of larger than 300 people on 12 March	School measure since 11/3				Closing country border, National Emergency Declaration on 16 March	**(Incidence):** Before the implementation of social distancing measures in Lima, the mean scaling of growth parameter, p, was estimated at 0.9 and the reproduction number at 2.3. School closures and other social distancing interventions slowed down the spread of the novel coronavirus, shifting the exponential growth trend to an

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date of symptoms onset								approximately linear growth trend, with the scaling of growth parameter being reduced to 0.53.
Pan et al.(33); Research article; 8/12/2019– 8/3/2020 Cohort study on data of 32 583 patients	China Wuhan; Middle	Social distancing			Traffic restriction	Cordons sanitaire	Universal symptom survey, home and centralized quarantine	**(Infectivity):** A reduction of R_t from larger than 3 in January to less than 1.0 on February 6 and then less than 0.3 in March after implementation of measures by different phases.
Patel P et al.(53); Research article; 30/1– 4/5/2020 Epidemiology study using the growth rate of confirmed cases	India; Middle	✓	✓	✓		Lockdown since 25 March	progressive travel restriction, health promotion and enhanced testing	**(infectivity):** A decline in Rt following NPIs implementation was observed, with a reduction from 2.51to 1.83 at the end of lockdown phase. Although the sub-exponential growth confirmed mitigation of epidemic, R_t larger than 1 still indicated ongoing disease transmission.
Randhawa et al.(29); Research letter; 1/3/20-16/4/20. Analysis of the positivity rates for SARS-CoV-2 in outpatient settings In Washington State and in emergency departments in Seattle	The US High	Statewide gathering limits		Statewide shut down of bars and restaurants		Washington State's stay-home order		**(Incidence):** The positivity rate was 17.6% in the outpatient clinics and 14.3% in emergency departments at the peak period and 3.8% and 9.8%, respectively, at the end of the analysis period.
Rivkees et al. (23); Brief report; 1/3/2020-31/5/2020	Florida, US High	✓	Closures of elementary schools, high	Restricted access to bars and restaurants, limited	✓	Statewide stay-at-home order		**(Attendance)** Assessment of movement within the state using Google mobility and Unacast mobility analytics based on cell phone data showed that closing schools resulted in a 40-55% reduction in average

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			schools, and universities for in-person classes	commerce to essential businesses				distance traveled compared with pre-outbreak levels. The stay-at-home order was associated with a further reduction in average distance traveled. During the period under stay-at-home order, the density of in-person encounters fell by 74-82%, visits to nonessential venues by 55%, and overall distance traveled by 45%. Average distance traveled within the state decreased by 25-40%.
Rubin et al. (19) Research article; 25/2/2020- 23/4/ 2020 Cohort study using publicly de-identified data	The US; High	✓		Reduce visits to nonessential businesses				**(Infectivity):** In multivariable analysis, a 50% decline in visits to nonessential businesses was associated with a 45% decline in R_t (95%CI, 43%-49%). With a 70% decrease in visits to nonessential business, a fall below a threshold R_t of 1.0 was estimated in 202 counties (95.7%), including 17 of 21 counties (81.0%) in the top density decile and 52 of 53 counties (98.1%) in the lowest density quartile.
Saez et al. (54) Research report; 17/1/2020-5/4/2020 Time series analysis on the new daily cases	Spain High	Reducing travel, avoiding crowded places, using non-contact greetings	✓	Closure of workplaces, stadiums, cinemas, theatres and restaurants		✓	Quarantines, travel restrictions	After implementing the measures for one day, the variation rate of accumulated cases decreased daily by 3.059 percentage points on average (95% credibility interval: −5.371,−0.879) and the decline was greater when time passed and reached 5.11 percentage points on the last day of data collection. Despite not entering the decrease phase, the measures taken by the Spanish Government on March 14, 2020 managed to flatten the curve.
Siedner et al. (25); Research article;	All 50 states of the US, High	Statewide social distancing	✓	✓	Restrictions on internal movement			**(Incidence)** The mean daily COVID-19 case growth rate dropped by 0.9% per day,

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10/3/2020-26/5/2020 Longitudinal pretest–posttest comparison study of incidence and mortality		measures with cancellation of public events			and closure of state borders			starting 4 days after implementation of the first statewide social distancing measures. **(Mortality)** After implementing social distancing for 7 days, the COVID-19-attributed mortality growth rate fell by 2.0% per day, although this decline was no longer statistically significant by 10 days.
Thu et al.(38); Research article; 11/1 – 2/5/2020 Time-series analysis based on daily cases	10 countries: the US, Spain, Italy, UK, France, Germany, Russia, Turkey, Iran and China; Middle to High	Cancellation of public events	✓	Work from home, cancellation of non-essential events	Domestic transportation restriction	By region and, by nationwide, by different phases	Entry restrictions to those from highly infected areas	**(Incidence):** Growth rates of daily confirmed cases in the UK and the US were the most severe, at 99.9%, followed by Spain at 99.2%, France at 96.2%, Italy at 95.4%, Germany at 85%, Russia at 72.2%, Turkey at 70.7% and Iran at 62.8%. Countries with high growth rate showed lower decline rate, showing longer time needed for those countries to control the epidemic by social distancing measures.
Vokó et al.(55); Research article; 1/2/2020-18/4/2020 Modelling study using daily new cases	28 European countries; High	Social distancing with public event ban	✓	✓	✓	✓		(Incidence) Incidence of new COVID-19 cases grew by 24% per day on average before the changepoint. From the changepoint observed, the growth rate was reduced to 0.9%, 0.3% increase, and to 0.7% and 1.7% decrease by increasing social distancing quartiles based on Social Distance Index (SDI) calculated based on Google Community Mobility Reports.
Wan et al.(30); Research article; 20/1/2020-3/3/2020 Modelling study using incidence data, with death and recovery cases	Mainland of China excluding Hubei; Middle	Social distancing and self-isolation			✓		Close contact tracing, body temperature measurement	**(Infectivity)** R_t has dropped sharply from 3.34 on 20 January 2020 to 0.89 on 31 January 2020, after integrated control strategies were implemented.

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Weill et al. (18); Research article; 1/1/2020-21/4/2020 Event study design on behavior subsequent to state emergency orders	The US; High	✓		business closures		Safer-at-home orders		**(Attendance):** Median distance traveled, retail and recreation, locations visited by a mobile device per day showed a sharp decrease in March after the implementation of social distancing measures, with the wealthier areas decreasing mobility more significantly than poorer areas. However, the trend shifted reversely after March regarding completely staying at home. People from wealthier areas shifted from the lowest before March to the most likely to completely stay at home after March, vice versa for those in poorer countries.
Wilasang et al.(56); Research article; From the date of 100 cases to 7/4/2020 Analysis on the number of daily new cases and the distribution of the serial interval	10 countries: Belgium, China, France, Germany, Iran, South Korea, Spain, Thailand, US and UK; Middle to High	✓				✓	Active case finding	**(Infectivity):** After 3-week control measures, only China and South Korea were successful in controlling the disease (R_t <1), while the others were unsuccessful. The study observed that countries with active case-finding and prompt isolation could have a reduction in the reproduction number more rapidly.
Yehya et al.(57); Research article; 21/1-29/42020 Ecological study using secondary data to analyze relationship between timing of	The US; High		School closure				Declaration of Emergency	**(Mortality):** Each day of delay of either intervention increased mortality risk by 5-6%.

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interventions and mortality								
Zhang et al.(32); Research article; 24 – 30/12/2019 as baseline and 1-10/2/2020 as outbreak period Analysis on contact survey data reported by 1,193 study participants	Wuhan and Shanghai; Middle		✓		✓			**(Attendance):** Daily contact frequency in Wuhan showed a reduction from 14.6 to 2.0 while Shanghai from 18.8 to 2.3. The trend was consistent with mobility data of an 86.9% and a 74.5% drop in Wuhan and Shanghai respectively.
Zhang et al. (58); Research article; 23/1– 9/5/2020 Analysis of the changes in incidence	Wuhan (China), Italy and the US; Middle to High	✓				Stay-at-home	Face mask	**(Incidence):** Daily new infection in New York decreased with a slope of 106 cases per day (decreasing rate at around 3%) after face mask-on policy, while US (excluding New York) increased with a slope of 70 cases per day (increasing rate at around 0.3%). The decreasing rate in the daily new infections in New York with face covering mandate was proportionately higher than that in the United States with only social distancing and stay-at-home order, illustrating the importance of face covering on stemming the virus spread. With mask-on policy, Italy showed an infection reduction by over 75,000 from April 6 to May 9.
58th SAGE meeting summary (22); Review;	The UK; High					Lockdown, short stay-at-home order		**(Infectivity):** Lockdown was very impactful and reduced R_t from 2.7 to 0.6. 2-3 week short stay-at-home order had moderate impact on reducing R_t to less than 1. Both showed high confidence correlation.

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		Decreasing contact between households, closure of worship/ community centers, restriction on outdoor gatherings						**(Infectivity):** Moderate impact was found by stopping contacts among different households, reducing R_t by around 0.1-0.2. Low to moderate impact was shown following closure of worship/ community centers, with a potential reduction in R_t up to 0.1. Low impact came with the restriction on outdoor gatherings, with R_t being reduced to less than 0.05, considering the frailty of SARS-CoV2 under well-ventilated environment.
					Local 5-mile travel restriction, use of public transport restricted to key workers			**(Infectivity):** The impact of 5-mile travel restriction was considered as low to moderate, with limited benefit especially when local outbreak was widespread. Restricted use of public transport to key workers might have low impact due to low level of crowding, mandated face-mask policy and inconclusive evidence of the transmission risk in public transport.
			Mass / reactive school closure, closure of class with infection, alterative school schedules with half class sizes, closure of further/ high					**(Infectivity):** Moderate impact of closing all schools was found, with a reduction in R_t of 0.2~0.5 while closing secondary schools was considered to be more effective, with a Rt drop of 0.35. Reactive school closure might have a moderate impact on the reduction in R_t of 0.12 ~ 0.45 whereas low to moderate impact was estimated for reactive closure of class with infection. Alternative school schedules with reduced class size were suggested to have moderate to low impact. Closure of further / higher education associated with moderate impact

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			education or childcare					while closure of childcare might have low to moderate impact.
				Work from home, alternate work, closure of bars/ pubs/ cafes/ restaurants, closure of gym/ leisure centers, non-essential retail, personal services, adherence to "COVID security" arrangement in workplaces				**(Infectivity):** Moderate impact of work from home was evaluated with a R_t reduction of 0.2-0.4 if all people followed while low to moderate impact with a R_t drop up to 0.1 was estimated for alternate work. Moderate impact with potential reduction in R_t of 0.1-0.2 was predicted for the closure of bars/pub/restaurants. Closure of gym/ leisure centres associated with low to moderate impact, with potential reduction in R_t of up to 0.1. Impact of closure of non-essential retail and personal services was estimated to be limited. Adherence to "COVID security" in workplaces such as improved hand/ surface hygiene and added barrier setting was also considered as low impact.
ECDC (11); Review; Published on 24 Sept 2020	Members of the EU countries; High					Stay-at-home		**(Infectivity):** R_t reduced by 18% (ranging from 4-31%).
		Physical distance between 1-2m						**(Infectivity):** Physical distancing of 1 metre or more was linked to an approximately five-fold reduction of the transmission risk, with the protective effect being doubled for every extra metre added.
					Domestic travel restrictions: a cordon sanitaire or public			**(Infectivity):** There were contradictory results on R_t among the studies. Modelling showed strong association while other studies showed no impact unless other NPI was put in place, e.g., physical distancing. It

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					transportation closure			was difficult to relate observed changes in transmission dynamics to a single measure.
			School closure					**(Incidence):** Observational data suggested that reopening schools has not been associated with significant increases in community transmission.
				Work from home, flexible working time and social distancing measures, closure of non-essential businesses				**(Infectivity):** There was a 40% R_t reduction by closing most of non-essential businesses while 31% by closing high risk businesses, e.g., restaurant/ bars/ nightclub/ cinemas/ gym.

Table 3 Comparison of the major outcomes of different types/levels of social distancing

	Social distancing between individuals	School closure	Workplace measures	Public transport restriction	Partial lockdown	Full lockdown
Relative frequency and consistency of evidence#	Adequate	Moderate	Limited	No	Adequate	Adequate
(Infectivity): Rt, effective reduction number	Physical distancing of 1 meter or more could reduce the transmission risk by 5 times and the protective impact was double for every extra meter (16). Estimated R_t reduced by 36%, 28% and 12% when gatherings were limited to 10, 100 and 1,000 people respectively (17).		Estimated 29% R_t reduction by closing most of non-essential businesses while 20% by closing high risk businesses (17). In the US, a 50% decline in visits to nonessential businesses was associated with a 45% decline in Rt [95%CI, 43%-49%] (19).	No difference in reduction in R_t (10).	In Mainland China excluding Hubei (province of Wuhan), R_t dropped from 3.34 to 0.89 (30). In 58 cities of China, R_t dropped by 54.3% (31).	From data of 41 countries, estimated R_t reduced by 10% by stay-at-home orders (−2%–22%) (17). UK estimation suggested that country lockdown could reduce R_t from 2.7 to 0.6 while 2-3 week short stay-at-home order had moderate impact by reducing R_t to below 1 (22). China R_t reduced from 2.35 to 1.05 during the lockdown (49).
(Incidence): Infection incidence/ ratio of incidence rate ratio/ attack rate/ bed occupancy rate	In the US, COVID-19 infection was less likely among the public who always practiced social distancing (aOR for indoor social distancing, 0.32 [95% CI, .10–.99]; aOR for outdoor social distancing, 0.10 [95% CI, .03–.33] (20).	In the US, school closure decreased COVID-19 incidence (adjusted relative change per week, −62%) (24). Observational data from a number of the EU countries suggested that re-opening of schools was not associated with increase of			In the US, mean daily COVID-19 case growth rate decreased by 0.9% per day four days after lockdown (25).	Data from 32 countries showed decreased incidence of COVID-19 (pooled incident rate ratio, IRR 0.87, 0.84 to 0.91) (10). Growth rate of daily confirmed cases reduced by 5.4% after 1-5 days, 6.8% after 6-10 days, 8.2% after 11-15 days, 9.1% after 16-20 days (37).

		community transmission (11).				
(Mortality): Mortality/ fatality rate		In the US, school closure decreased COVID-19 related mortality (−58%) (24).			In the US, COVID-19-attributed mortality growth rate decreased by 2% per day seven days after lockdown (25).	
(Effect time): Action and effect duration / time of reaching peak					In 58 cities of China, mean time until successful containment was 8 days (31).	
(Attendance): Attendance % of location/ daily vehicles miles/ daily contact frequency/ mobility of leaving home/ distance travel		In Florida, the US found that closing of schools resulted in a 40-55% reduction in average distance traveled (23).			In Spain, self-reported walking time decreased by 58.2% (46).	In Wuhan and Shanghai, the average daily number of contacts dropped from 14.6 to 2 and 18.8 to 2.3 respectively during lockdown. Mobility dropped 86.9% and 74.5% in respective areas (32). Stay-at- home order in Florida of the US resulted in a reduction of in-person encounters by 74-82%, visits to nonessential venues by 55%, and overall distance traveled by 45% (23).

Relative frequency and consistency of evidence based on the studies reviewed, without risk of bias assessment

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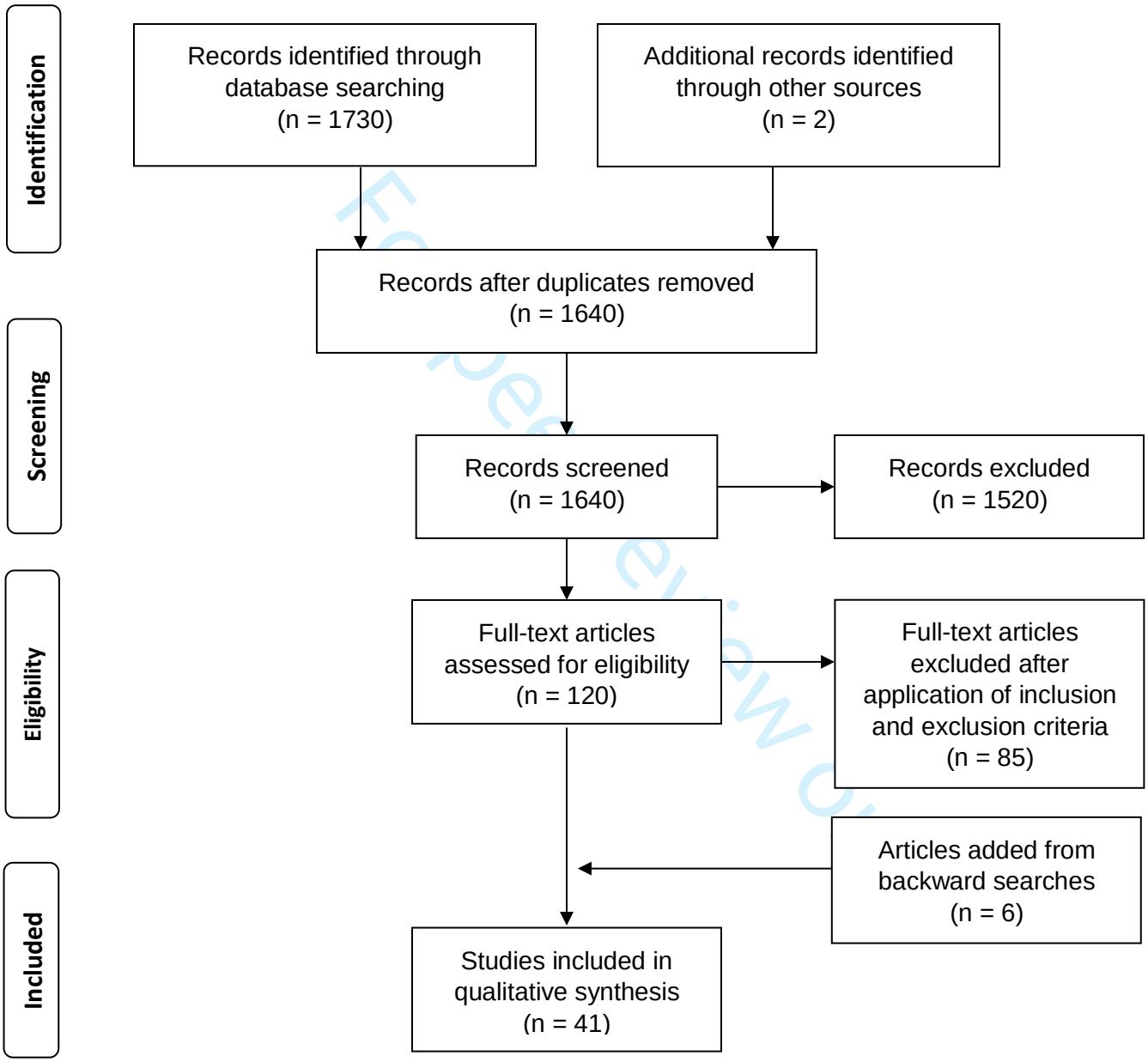
Figure 1. PRISMA flow diagram of literature search and selection



Databases and search period:
7 databases were selected and searched through Ovid platform.

AMED (Allied and Complementary Medicine) 1985 to September 2020**, Embase** 1910 to Present**, Global Health** 1973 to 2020 Week 40**, Ovid MEDLINE(R)** 1946 to September 30, 2020**, Ovid Nursing Database** 1946 to September Week 4 2020**, APA PsycInfo** 1806 to September Week 4 2020**, Social Work Abstracts** 1968 to September 2020

Search terms:
Sensitive search was conducted using these syntax, which included a higher number of articles (compared with specific search). Duplicated articles were removed after the searches.

"COVID*".m_titl. AND social distan*.ab.
"COVID*".m_titl. AND physical distan*.ab
"SARS-CoV-2*".m_titl. AND (social distan* or physical distan*).ab.

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	1
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	4-5
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	5
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Click here to enter text.
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	6
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	6
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	6
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	6-7
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	7
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	8
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	Click here to enter text.

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	7
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	7
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	8-13, 24-35
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	Click here to enter text.
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	24-35
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	8-13, 36-37
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	13-14
Limitations	20	Discuss the limitations of the scoping review process.	18
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	19
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	20

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMAScR): Checklist and Explanation. Ann Intern Med. 2018;169:467–473. doi: 10.7326/M18-0850.