


# BMJ Open 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 synthesise 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 for the combined effect of different social distancing interventions than for a single intervention. As fatigue of preventive behaviours is an issue in public health agenda, future studies should analyse the risks in specific settings such as eateries and entertainment to implement and evaluate measures which are proportionate to the risk.

## INTRODUCTION

Social distancing is one of the main non-pharmaceutical interventions (NPIs) to

## Strengths and limitations of this study

- First scoping review to synthesise 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.

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. WHO guidelines describe social distancing measures at the individual level (eg, keeping at least one metre from each other) and the community level including stay-at-home recommendation/ordinances and measures in specific socioeconomic settings (eg, workplace, schools, eateries, entertainment and parties).<sup>1 2</sup> 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,<sup>3 4</sup> where it can be a total or partial lockdown to restrict key socioeconomic activities.<sup>5</sup>

Despite the fact that social distancing measures have become a crucial strategy globally in mitigating COVID-19 pandemic, the evidence for their effectiveness is just slowly accruing. Earlier studies applied mathematical modelling to predict effectiveness

of social distancing measures.<sup>6-9</sup> Recent studies evaluated the outcomes retrospectively using empirical data and reported the outcomes within specific parameters. A study which analysed data from 149 countries suggested that implementation of different social distancing interventions was associated with an overall reduction in COVID-19 incidence of 13% (incident rate ratio, IRR 0.87, 95% CI 0.85 to 0.89).<sup>10</sup> It concluded that data from 11 countries indicated similar overall effectiveness (pooled IRR 0.85, 95% CI 0.81 to 0.89) when school closures, workplace closures and restrictions on mass gatherings were in place.<sup>10</sup> 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.<sup>11</sup> 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 socioeconomic life, which have led to fatigue in preventive behaviours. In this context, targeted measures which have been evaluated to be proportionate to the risks should motivate continuing preventive behaviours.

This study aims to synthesise 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 synthesise the current evidence, clarify conceptual parameters and identify gaps for further research.<sup>12-14</sup>

### 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.

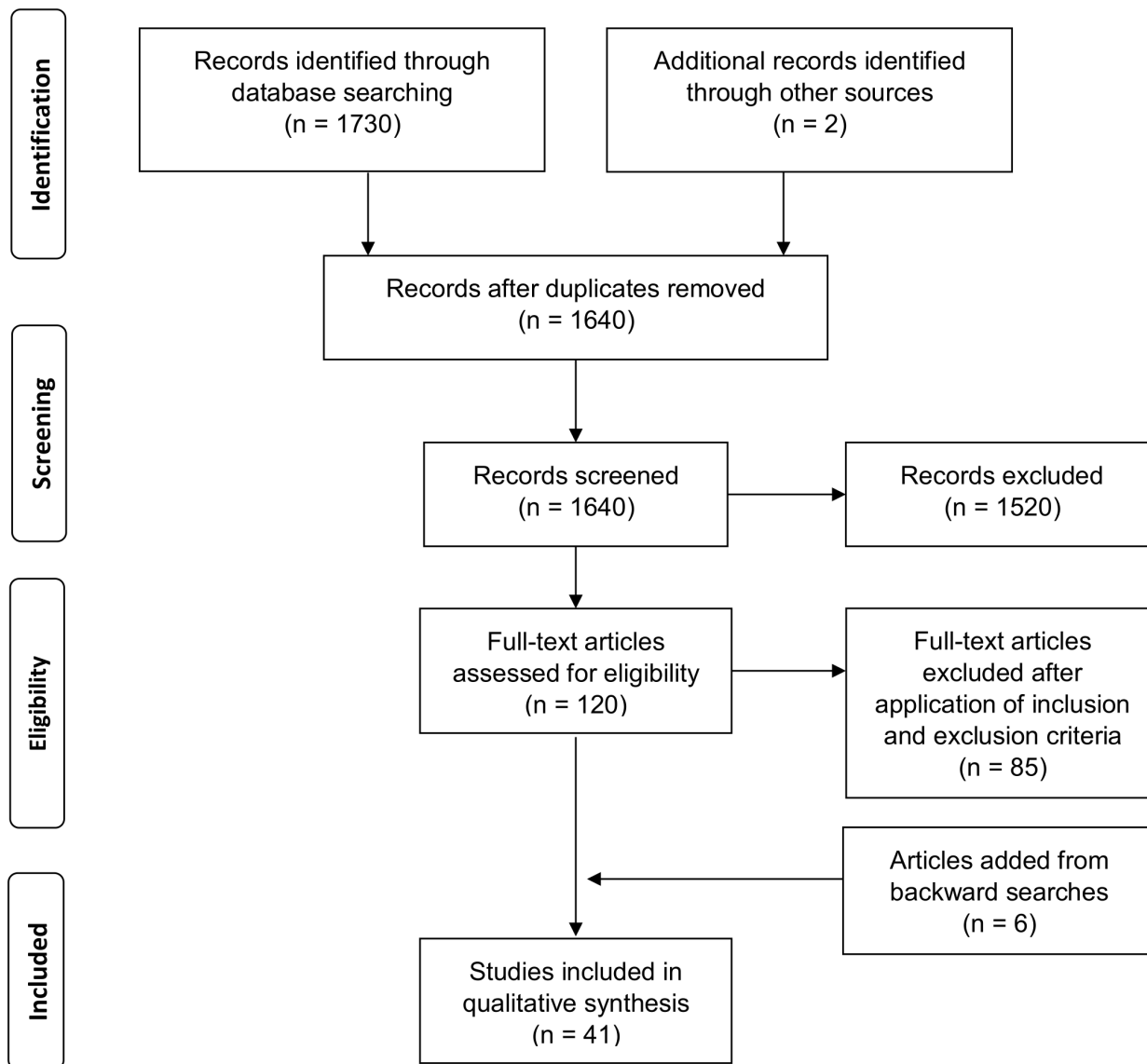
Exclusion criteria were: (1) qualitative studies, commentaries, mini-reviews without search strategies, editorials, conference presentations, dissertations and book chapters); (2) non-English articles; (3) studies in healthcare settings, such as those on healthcare workers, hospital patients and elderly 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 online supplemental file 1. 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 Preferred Reporting Items for Systematic Reviews and Meta-Analyses - Extension for Scoping Reviews (PRISMA-ScR).<sup>15</sup> 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,<sup>15</sup> 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.<sup>15</sup>

### Data extraction and synthesis

For each study included, texts under the headings of 'results' or 'findings' were extracted and analysed 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.



**Figure 1** PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses - Extension for Scoping Reviews) flow diagram of literature search and selection.

### 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.

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](#) summarises the key findings based on the following effectiveness indicators: (1) Infectivity:  $R_r$ , 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

**Table 1** Article characteristics (n=41)

|                                       | Count (%) |
|---------------------------------------|-----------|
| Countries/cities by geographic region |           |
| Asia                                  | 13 (27.7) |
| Australia and 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.

is also given. A tick “✓” is put if no detailed elaboration was provided in the reviewed articles.

### 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 relationship between the transmission risk and the level of social distancing. A meta-analysis including seven studies on COVID-19 concluded that physical distancing of 1 m or more was effective in reducing the transmission risk by five times and the protective impact was double for every extra metre.<sup>16</sup> Similarly, based on the chronological data on interventions in 41 countries between January and May 2020, Brauner *et al*<sup>17</sup> estimated that  $R_t$  reduced by 36%, 28% and 12% when gatherings were limited to 10, 100 and 1000 people, respectively. Furthermore, studies found how mobility changed according to different social distancing measures. A study by Weill *et al*<sup>18</sup> in the US. A found that median distance travelled, 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  $R_t$ .<sup>19</sup> 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  $R_t$ .<sup>19</sup> Another US study by Clipman *et al*,<sup>20</sup> 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 0.10 to 0.99]; adjusted OR for outdoor social distancing, 0.10 (95% CI 0.03 to 0.33)), giving indications of the effect of mobility on the pandemic. It was consistent with the inference by Lemaitre *et al*<sup>21</sup> who found a strong support for changes in  $R_0$  following the mobility decline before implementation of school closure, underlining the importance of behaviour 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<sup>22</sup> 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 level of closures and the unexpected link between school closure and reopening. Rivkees's<sup>23</sup> study in Florida of the USA found that closing schools resulted in a 40%–55% reduction in average distance travelled compared with preoutbreak levels. Moreover, Auger *et al*<sup>24</sup> found that the primary and secondary school closure in the USA 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<sup>22</sup> 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.<sup>25</sup> Contrary to expected impacts of school closures, observational data in ECDC review suggested that reopening schools had not been associated with significant increases of community transmission.<sup>11</sup> In other studies<sup>26 27</sup> that focused on the various measures used in educational and children care centre settings after reopening, the results showed a 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. However, the specific impact of reduction of face-to-face attendance in classrooms was not assessed.<sup>28</sup>

#### Workplace measures

Workplace measures include work-from-home arrangement, measures in working environment and closure

**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                   |  |
| Auger <i>et al</i><br>Research article;<br>9/3/2020–7/5/2020;<br>Population-based observational study of changes in incidence and mortality <sup>24</sup>                         | The US;<br>High                      |                                       | Statewide closure of primary and secondary schools |  |                              |   |                          | Infectivity: $R_t$ , effective reduction number<br>Incidence: Incidence, incidence rate, attack rate, bed occupancy rate<br>Mortality: Mortality or fatality rate<br>Effect time: Action and effect duration, time of reaching peak<br>Attendance: Attendance % of location, daily vehicles miles, daily contact frequency, mobility of leaving home, travel distance  |
| Brauner <i>et al</i><br>Research article;<br>22/1/2020–30/5/2020;<br>Modelling study based on national case and death counts <sup>17</sup>  | Members of the EU countries;<br>High | Limiting size of gathering            |  | Closing most of non-essential businesses and high-risk businesses, for example, bars and restaurants |                              |   |                          | (Incidence and mortality): Primary and secondary school closure in the USA 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.<br>(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 1000 or below. A 29% $R_t$ reduction came with closing most of non-essential businesses while 20% was found when closing high risk businesses, for example, bars and restaurants. |
| Castaneda-Babarro <i>et al</i> ;<br>Research article;<br>23/3/2020–1/4/2020;<br>Cross-sectional survey on 800 general public for walking time <sup>46</sup>                       | Spain;<br>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 <i>et al</i> ;<br>Research article;<br>17–28/6/2020<br>Cross-sectional survey on 1030 general public for infection history and social distancing behaviours <sup>20</sup> | Maryland, the US;<br>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 0.10 to 0.99); aOR for outdoor social distancing, 0.10 (95% CI 0.03 to 0.33).   |
| Cruz;<br>Research article;<br>15/3 to 5/4/2020;<br>Time series analysis of death counts <sup>40</sup>   | São Paulo City, Brazil;<br>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.   |

Continued

**Table 2** Continued

| 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 closure/ measure/ closure   | Workplace measure/closure  | Public transport restriction                           | Stay-at-home recommendations/ ordinances | Others  | Effectiveness indicators  |
| Courtemanche <i>et al</i> Research article; 1/3 – 27/4/2020; Analysis of growth rate of cases <sup>37</sup>                                       | 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)     |   | <p><b>Effectiveness indicators</b></p> <p>Infectivity: <math>R_t</math>, effective reduction number</p> <p>Incidence: Incidence, incidence rate, attack rate, bed occupancy rate</p> <p>Mortality: Mortality or fatality rate</p> <p>Effect time: Action and effect duration, time of reaching peak</p> <p>Attendance: % of location, daily vehicles miles, daily contact frequency, mobility of leaving home, travel distance</p>  |
| Du <i>et al</i> ; Research article; 1/1 - 15/2/2020; Analysis of case data from online reports <sup>31</sup>                                      | 58 cities of China; Middle     | Ban on public gathering                                 | ✓  | Closing shopping malls, restaurants and entertainment businesses | Suspension of intracity and intercity public transport | ✓  | Testing   | <p>(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.</p> <p>(Infectivity): <math>R_t</math> declined by an average of 54.3% (<math>\pm 17.6\%</math>) during the containment period.</p> <p>(Effect time): The mean time until successful containment was 21 days after the first reported case and 8 days following the initiation of interventions. During the period of containment, the <math>R_t</math> declined by an average of 54.3%. A delay of 1 day in implementing the first intervention is expected to prolong an outbreak by 2.41 days (95% CI 0.96 to 3.86)</p> |
| Enrhardt <i>et al</i> ; Research letter; 25/5/20-25/8/20 COVID-19 cases aged 0–19 years who attended schools / childcare facilities <sup>27</sup> | Germany; High                  |   | 50% class size reduction, cancelling physical education lesson, physical distancing between children |  |  |  | Enhance ventilation of 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 | <p>(Incidence): The infection for children aged 0–19 was 3.3% among all settings, 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.</p>  |

Continued

**Table 2** Continued

| Article and study characteristics  | Type of social distancing measures   |  |  |                              |                                 | Effectiveness indicators                      |  |   |
|--|--------------------------------------|--|--|------------------------------|---------------------------------|---|--|---|
|  | Country/<br>region;<br>economy/level | Social<br>distancing<br>between<br>individuals   | School<br>measure/<br>closure  | Workplace<br>measure/closure | Public transport<br>restriction | Stay-at-home<br>recommendation/<br>ordinances | Others   |   |
| <p>Otte <i>et al</i>;<br/>Research letter;<br/>28/1/20 – 31/8/20<br/>Analysis of COVID-19<br/>data on school outbreaks<br/>using national surveillance<br/>system<sup>26</sup></p> | <p>Germany;<br/>High</p>             |  | <p>Opening<br/>school for<br/>specific<br/>grades,<br/>staggering<br/>timetables,<br/>alternating<br/>between<br/>remote<br/>and on-site<br/>teaching,<br/>restricting<br/>class size,<br/>keeping<br/>distance<br/>between<br/>students</p> |                              |                                 |   | <p>Policies for sick students<br/>and staff to stay home,<br/>enhanced hand hygiene,<br/>wearing face masks,<br/>ventilation of rooms,<br/>respiratory etiquette</p>   | <p><b>Effectiveness indicators</b><br/>Incidence: <math>R_t</math>, effective reduction number<br/>Incidence: Incidence, incidence rate,<br/>attack rate, bed occupancy rate<br/><b>Mortality: Mortality or fatality rate</b><br/><b>Effect time: Action and effect duration,</b><br/>time of reaching peak<br/>Attendance: Attendance % of location,<br/>daily vehicles miles, daily contact<br/>frequency, mobility of leaving home,<br/>travel distance<br/><b>(Incidence):</b> The average number of<br/>outbreaks and of cases per outbreak was<br/>smaller after reopening of schools (2.2<br/>outbreaks/week and 4 cases/ outbreak)<br/>than before school closure (3.3 outbreaks/<br/>week and 6 cases/outbreak).</p> |
| <p>Huynh;<br/>Research article;<br/>16/2 - 29/3/2020;<br/>Analysis of data from<br/>community mobility<br/>reports<sup>41</sup></p>  | <p>58 countries;<br/>Low to high</p> | <p>Social<br/>distancing in:<br/>1. retail and<br/>recreation<br/>2. grocery and<br/>pharmacy<br/>3.parks<br/>1. transit<br/>stations<br/>2. workplaces<br/>6.<br/>residential<br/>areas</p> |  |                              |                                 |   | <p><b>(Attendance):</b> Attendance in percentage<br/>change of specific locations was reported.<br/>Countries with higher Uncertainty<br/>Avoidance Index (UAI) predicted lower<br/>proportion of people gathering in public<br/>such as retail and recreation, grocery<br/>and pharmacy, parks, transit stations,<br/>workplaces. Northern Europe (Finland,<br/>Sweden and Norway) with lower UAI was<br/>unlikely to commit to social distancing. The<br/>cultural determinants played an important<br/>role in controlling infection behaviour.</p> |   |

Continued



Table 2 Continued

| 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  |
| Islam <i>et al</i> ;<br>Research article;<br>1/1 – 30/5/2020;<br>Natural experiment with interrupted time series analysis <sup>10</sup>                | 149 countries;<br>Low to High      | Restriction of mass gathering and public events | School closure          | Workplace closure  | Public transport closure     | Movement Lockdown                       |   |
| Jarvis <i>et al</i> ;<br>Research article;<br>24/3-27/3/2020;<br>Cohort survey on 1356 general public to report daily number of contacts <sup>47</sup> | The UK;<br>High                    |   | School closure          | Limiting time at work, having work closed and/or not visiting work |                              | Quarantine and isolate                  | <b>(Incidence):</b> 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, 95% CI 0.84 to 0.91).<br><b>(Attendance):</b> 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% CI 0.37 to 0.89) after the lockdown, based on all types of contact and 0.37 (95% CI 0.22 to 0.53) for physical contacts only. |
| Lemaitre <i>et al</i> ;<br>Research article;<br>24/2/2020-24/4/2020<br>Modelling study using data on hospitalisations and deaths <sup>21</sup>         | Switzerland;<br>High               | Ban on gathering                                | School closure          | Closure of nonessential activities                                 |                              |   | <b>(Infectivity):</b> 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).<br><b>(Incidence):</b> 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 to 0.79), school closure (RRR 0.63, 95% CI 0.57 to 0.79), business closure (RRR 0.62, 95% CI 0.45 to 0.85).   |
| Jüni <i>et al</i> ;<br>Research article;<br>7– 13/3/2020;<br>Prospective cohort study for incidence <sup>48</sup>                                      | 144 countries;<br>Low to High      | Gathering of any size                           | ✓<br>School closure     | Closing restaurants, bars, or non-grocery stores                   |                              |   |   |

Continued



**Table 2** Continued

| 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  | Effectiveness indicators   |
| <p>Khanna <i>et al</i>;<br/>Review;<br/>Published on 10 April 2020;<sup>49</sup></p> <p>Analysis of effect of measures indicated by Rt<sup>36</sup></p>   | <p>China, HK, Singapore, South Korea, USA, Italy, Spain, Iran and India;<br/>Middle to High</p> | <p>Cancellation of public events, restrictions on size of gatherings,</p> | <p>Reduced face-to-face attendance</p> | <p>Closure of workplace</p> | <p>All transports in and out of Hubei were prohibited, with each citizen being allowed to go out for 30 min every 2 days</p> | <p>3 weeks lockdown in Hubei</p>        | <p>Quarantine of mild and asymptomatic cases for China Travellers</p>   | <p><b>Infectivity:</b> <math>R_t</math>, effective reduction number<br/>Incidence: incidence, incidence rate, attack rate, bed occupancy rate<br/><b>Mortality:</b> Mortality or fatality rate<br/><b>Effect time:</b> Action and effect duration, time of reaching peak<br/>Attendance: Attendance % of location, daily vehicles miles, daily contact frequency, mobility of leaving home, travel distance<br/><br/> <b>(Infectivity):</b> China <math>R_t</math> reduced from 2.35 to 1.05 during the period of 16/1/2020–30/1/2020.<br/> <b>(Effect time):</b> China slowed the dispersal of infection to other cities by 2.91 days and increased the doubling time from 2 to 4 days.<br/>                     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.</p> |
| <p>Koh <i>et al</i>;<br/>Research report;<br/>1/1/2020–28/5/2020</p>  | <p>142 countries;<br/>Low to High</p>   | <p>✓</p>  | <p>✓</p>                               | <p>Closure of workplace</p> | <p>Closures of public transport</p>  | <p>Stay-at-home order</p>               | <p>Restrictions on internal movements/ international travel</p>   | <p><b>(Infectivity):</b> Following the 100th case, it was found effective that complete travel bans and all forms of lockdown-type measures reduced average <math>R_t</math> 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.</p>  |
| <p>Macartney <i>et al</i>;<br/>Research article;<br/>25/1/20–10/4/20.</p> <p>Analysis of confirmed cases in children and staff who attended schools or early childhood education and care settings<sup>28</sup></p> | <p>Australia;<br/>High</p>  | <p>✓</p>  | <p>Reduced face-to-face attendance</p> | <p>Work from home</p>       | <p>Work from home</p>  | <p>Work from home</p>                   | <p>Border Control<br/>▲ Phases 1–3: (18/1–7/2)<br/>▲ Phase 4: (8–29/2)<br/>Mandatory quarantine for China travellers in phase 4</p> | <p><b>(Incidence):</b> 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</p>   |
| <p>Lai <i>et al</i>;<br/>Research article;<br/>23/1 – 1/3/2020;<br/>Epidemiological study analysing government information of the confirmed cases<sup>50</sup></p>  | <p>Hong Kong;<br/>High</p>  | <p>✓</p>  | <p>✓</p>                               | <p>Work from home</p>       | <p>Work from home</p>  | <p>Work from home</p>                   | <p>Border Control<br/>▲ Phases 1–3: (18/1–7/2)<br/>▲ Phase 4: (8–29/2)<br/>Mandatory quarantine for China travellers in phase 4</p> | <p><b>(Infectivity):</b> Median <math>R_t</math> dropped from 1.07 to 0.75 with border control in phase 4 (8–29/2/2020).</p>   |

Continued

**Table 2** Continued

| 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   |
| Lam <i>et al</i> ;<br>Research article;<br>1/1 – 31/5/2020;<br>Epidemiological study analysing the changes in daily number of confirmed cases <sup>39</sup>   | Hong Kong;<br>High  | Cancellation of large-scale events  | School suspension from phases 1–4 | Work from home for civil servants in phases 1 and 2 |   | Stay-at-home orders                         | Entry restriction / quarantine for inbound travellers and asymptomatic testing   |
| Lasry <i>et al</i> ;<br>Research article;<br>26/2 – 1/4/2020<br>Descriptive analysis using types and timing of mitigation interventions, cumulative number of reported cases, percentage change in confirmed cases and community mobility <sup>31</sup> | 4 US metropolitan areas: San Francisco, Seattle; New Orleans, and New York City;<br>High  | Ban on gathering of certain size  | School closure                    | Restrictions on businesses                          |   | Stay-at-home orders (last policy)           | States of Emergency (first policy)   |
| Lino <i>et al</i> ;<br>Research article;<br>1-31/5/2020<br>Observational study on bed occupation rates in a hospital following lockdown <sup>4</sup>  | Fortaleza (state capital city), Ceará, Brazil; Middle   | ✓<br>No social gathering or with people limit, 1–2m physical distance in public place |                                   | Suspension of commercial activities                 | Restricted daytime movements and interruption of intercity trips  | City lockdown, night curfews                | (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.<br>(Incidence): 3day average percentage change in cumulative case count showed a decreasing trend by the last 2 weeks of March after a set of policies implemented.                                     |
| Lim <i>et al</i> ;<br>Research article;<br>15/2/20-9/5/20.<br>Analysis of COVID-19 case counts from each Southeast Asian country collected from open web source <sup>34</sup>   | 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, 1–2m 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 | (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.<br>(Incidence): Average daily incidence declined gradually for all countries except the Philippines and Laos.<br>(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). |

Continued

**Table 2** Continued

| 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 recommendations/ordinances        | Others  |
| Marschner; Research article; 25/1 – 8/5/2020<br>Back-projection study analysing the probability distribution of the time between infection and diagnosis <sup>35</sup>  | 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)   |
| Munayco <i>et al</i> ;<br>Research article; 23/1 – 9/5/2020<br>Modelling study using the daily number of confirmed cases by date of symptoms onset <sup>32</sup>  | 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    |
| Pan <i>et al</i> ;<br>Research article; 8/12/2019 – 8/3/2020<br>Cohort study on data of 32 583 patients <sup>33</sup>   | China Wuhan; Middle           | Social distancing                                      |                           |  |                              |  | Universal symptom survey, home and centralised quarantine             |
| Patel P <i>et al</i> ;<br>Research article; 30/1 – 4/5/2020<br>Epidemiology study using the growth rate of confirmed cases <sup>43</sup>  | India; Middle                 | ✓  | ✓                         | ✓  |                              | Lockdown since 25 March                        | progressive travel restriction, health promotion and enhanced testing |
| Randhawa <i>et al</i> ;<br>Research letter; 1/3/20–16/4/20.<br>Analysis of the positivity rates for SARS-CoV-2 in outpatient settings in Washington State and in emergency departments in Seattle <sup>29</sup> | The US High                   | Statewide gathering limits                             |                           | Statewide shut down of bars and restaurants                                      |                              | Washington State's stay-home order             |   |

**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

**(Effect time):** It was estimated that 1 week delay in control measures would lead to an almost fivefold increase in total infections but 1 week earlier control would reduce total infections of similar magnitude.

**(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.

**(Infectivity):** A reduction of  $R_t$  from larger than three in January to less than 1.0 on February six and then less than 0.3 in March after implementation of measures by different phases.

**(infectivity):** A decline in  $R_t$  following NPIs implementation was observed, with a reduction from 2.51 to 1.83 at the end of lockdown phase. Although the sub-exponential growth confirmed mitigation of epidemic,  $R_t$  larger than one still indicated ongoing disease transmission.

**(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.

Continued

Table 2 Continued

| 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  |
| Rivkees <i>et al</i> ;<br>Brief report;<br>1/3/2020-31/5/2020 <sup>23</sup>  | Florida, US<br>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            | <p><b>(Attendance)</b> 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 travelled compared with pre-outbreak levels. The stay-at-home order was associated with a further reduction in average distance travelled. 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 travelled by 45%. Average distance travelled within the state decreased by 25%–40%.</p> |
| Rubin <i>et al</i> Research article;<br>25/2/2020– 23/4/2020<br>Cohort study using publicly de-identified data <sup>19</sup> | The US;<br>High                | ✓   |  | Reduce visits to nonessential businesses  |                              | ✓                                       | <p><b>(Infectivity):</b> In multivariable analysis, a 50% decline in visits to nonessential businesses was associated with a 45% decline in <math>R_t</math> (95% CI, 43% to 49%). With a 70% decrease in visits to nonessential business, a fall below a threshold <math>R_t</math> 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.</p>  |
| Saez <i>et al</i> Research report;<br>17/1/2020-5/4/2020<br>Time series analysis on the new daily cases <sup>54</sup>        | Spain<br>High                  | Reducing travel, avoiding crowded places, using non-contact greetings | ✓  | Closure of workplaces, stadiums, cinemas, theatres and restaurants                  |                              | ✓                                       | <p>After implementing the measures for 1 day, the variation rate of accumulated cases decreased daily by 3.059 percentage points on average (95% credibility interval: –5.371 to –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.</p>  |

Continued

Table 2 Continued

| 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  |  |
| Siedner <i>et al</i> ;<br>Research article;<br>10/3/2020- 26/5/2020<br>Longitudinal pretest–<br>posttest comparison study<br>of incidence and mortality; <sup>25</sup> | All 50 states of<br>the US,<br>High   | Statewide<br>social<br>distancing<br>measures with<br>cancellation of<br>public events | ✓                       | ✓   | Restrictions<br>on internal<br>movement and<br>closure of state<br>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.<br>(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 <i>et al</i> ;<br>Research article;<br>11/1 – 2/5/2020<br>Time-series analysis based<br>on daily cases; <sup>38</sup>  | ten countries:<br>the US,<br>Spain, Italy,<br>UK, France,<br>Germany,<br>Russia, Turkey,<br>Iran and China;<br>Middle to High | Cancellation of<br>public events   | ✓                       | Work from home,<br>cancellation of non-<br>essential events | Domestic<br>transportation<br>restriction                                  | By region and, by<br>nationwide, by<br>different phases | Entry restrictions to those<br>from highly infected areas | (Incidence): Growth rates of daily confirmed cases in the UK and the USA 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 <i>et al</i> ;<br>Research article;<br>1/2/2020-18/4/2020<br>Modelling study using daily<br>new cases; <sup>55</sup>  | 28 European<br>countries; High  | Social<br>distancing with<br>public event<br>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 SDI calculated based on Google Community Mobility Reports.  |
| Wan <i>et al</i> ;<br>Research article;<br>20/1/2020-3/3/2020<br>Modelling study using<br>incidence data, with death<br>and recovery cases; <sup>30</sup>              | Mainland of<br>China excluding<br>Hubei;<br>Middle  | Social<br>distancing and<br>self-isolation   |                         |   | ✓  |   | Close contact tracing, body<br>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.   |

Continued



Table 2 Continued

| Article and study characteristics   | Type of social distancing measures  | Effectiveness indicators  |
|---|---|---|
| <p><b>Authors; article type; study period/ publication date; study design</b></p> <p>Weill <i>et al</i>; Research article; 1/1/2020-21/4/2020<br/>Event study design on behaviour subsequent to state emergency orders<sup>18</sup></p> | <p><b>Social distancing between individuals</b></p> <p>✓</p> <p><b>Country/region; economy level</b></p> <p>The US; High</p> <p><b>School measure/ closure</b></p> <p></p> <p><b>Workplace measure/closure</b></p> <p>business closures</p> <p><b>Public transport restriction</b></p> <p></p> <p><b>Stay-at-home recommendation/ ordinances</b></p> <p>Safer-at-home orders</p> <p><b>Others</b></p> <p></p> | <p><b>Infectivity:</b> <math>R_t</math>, effective reduction number<br/><b>Incidence:</b> Incidence, incidence rate, attack rate, bed occupancy rate<br/><b>Mortality:</b> Mortality or fatality rate<br/><b>Effect time:</b> Action and effect duration, time of reaching peak<br/><b>Attendance:</b> Attendance % of location, daily vehicles miles, daily contact frequency, mobility of leaving home, travel distance</p> <p><b>(Attendance):</b> Median distance travelled, 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.</p> |
| <p><b>Wiliasang <i>et al</i>; Research article; From the date of 100 cases to 7/4/2020<br/>Analysis on the number of daily new cases and the distribution of the serial interval<sup>56</sup></b></p>                                   | <p>✓</p> <p>ten countries: Belgium, China, France, Germany, Iran, South Korea, Spain, Thailand, US and UK; Middle to High</p> <p>School closure</p> <p>Active case finding</p> <p>✓</p>   | <p><b>(Infectivity):</b> After 3 weeks control measures, only China and South Korea were successful in controlling the disease (<math>R_t &lt; 1</math>), 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.</p>   |
| <p><b>Yehya <i>et al</i>; Research article; 21/1-29/4/2020<br/>Ecological study using secondary data to analyse relationship between timing of interventions and mortality<sup>57</sup></b></p>   | <p>School closure</p> <p>Declaration of Emergency</p>   | <p><b>(Mortality):</b> Each day of delay of either intervention increased mortality risk by 5%–6%.</p>  |
| <p><b>Zhang <i>et al</i>; Research article; 24 – 30/12/2019 as baseline and 1-10/2/2020 as outbreak period<br/>Analysis on contact survey data reported by 1193 study participants<sup>32</sup></b></p>                                 | <p>✓</p> <p>Wuhan and Shanghai; Middle</p>  | <p><b>(Attendance):</b> 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.</p>  |

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Table 2 Continued

| 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   |   |
| Zhang <i>et al</i> ;<br>Research article;<br>23/1 – 9/5/2020<br>Analysis of the changes in incidence <sup>38</sup> | Wuhan (China),<br>Italy and the<br>US;<br>Middle to High | ✓   |                         |                           |                              | Stay-at-home                            | Face mask  | <p><b>(Incidence):</b> 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 USA (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 75000 from April six to May 9.</p> <p><b>(Infectivity):</b> Lockdown was very impactful and reduced <math>R_t</math> from 2.7 to 0.6. 2–3 week short stay-at-home order had moderate impact on reducing <math>R_t</math> to less than 1. Both showed high confidence correlation.</p> <p><b>(Infectivity):</b> Moderate impact was found by stopping contacts among different households, reducing <math>R_t</math> by around 0.1–0.2. Low to moderate impact was shown following closure of worship/ community centres, with a potential reduction in <math>R_t</math> up to 0.1. Low impact came with the restriction on outdoor gatherings, with <math>R_t</math> being reduced to less than 0.05, considering the frailty of SARS-CoV2 under well-ventilated environment.</p> <p><b>(Infectivity):</b> 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.</p> |
| 58th SAGE meeting summary;<br>Review <sup>22</sup>   | The UK;<br>High  |   |                         |                           |                              | Lockdown, short stay-at-home order      |  |   |
|  |  | Decreasing contact between households, closure of worship/ community centres, restriction on outdoor gatherings |                         |                           |                              |   | Local 5 mile travel restriction, use of public transport restricted to key workers |   |

Continued

Table 2 Continued

| 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  |
|   |                                   |                                       | Mass / reactive school closure, closure of class with infection, alternative school schedules with half class sizes, closure of further/ high education or childcare | Work from home, alternate work, closure of bars/ pubs/ cafes/ restaurants, closure of gym/ leisure centres, non-essential retail, personal services, adherence to "COVID-19 security" arrangement in workplaces |                              |   | <p><b>(Effectiveness indicators)</b></p> <p>Infectivity: <math>R_t</math>, effective reduction number</p> <p>Incidence: Incidence, incidence rate, attack rate, bed occupancy rate</p> <p>Mortality: Mortality or fatality rate</p> <p>Effect time: Action and effect duration, time of reaching peak</p> <p>Attendance: Attendance % of location, daily vehicles miles, daily contact frequency, mobility of leaving home, travel distance</p>   |
|   |                                   |                                       |  |   |                              |   | <p><b>(Infectivity):</b> Moderate impact of closing all schools was found, with a reduction in <math>R_t</math> of 0.2–0.5 while closing secondary schools was considered to be more effective, with a <math>R_t</math> drop of 0.35.</p> <p>Reactive school closure might have a moderate impact on the reduction in <math>R_t</math> of 0.12–0.45 whereas low to moderate impact was estimated for reactive closure of class with infection.</p> <p>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.</p> <p><b>(Infectivity):</b> Moderate impact of work from home was evaluated with a <math>R_t</math> reduction of 0.2–0.4 if all people followed while low to moderate impact with a <math>R_t</math> drop up to 0.1 was estimated for alternate work.</p> <p>Moderate impact with potential reduction in <math>R_t</math> of 0.1–0.2 was predicted for the closure of bars/pub/restaurants.</p> <p>Closure of gym/ leisure centres associated with low to moderate impact, with potential reduction in <math>R_t</math> of up to 0.1. Impact of closure of non-essential retail and personal services was estimated to be limited. Adherence to 'COVID-19 security' in workplaces such as improved hand/ surface hygiene and added barrier setting was also considered as low impact.</p> <p><b>(Infectivity):</b> <math>R_t</math> reduced by 18% (ranging from 4% to 31%).</p> <p><b>(Infectivity):</b> Physical distancing of 1 m or more was linked to an approximately fivefold reduction of the transmission risk, with the protective effect being doubled for every extra metre added.</p> |
| ECDC; Review; Published on 24 Sept 2020 <sup>11</sup>               | Members of the EU countries; High | Physical distance between 1–2 m       |  |   |                              | Stay-at-home                            |   |

Continued



**Table 2** Continued

| Article and study characteristics  | Type of social distancing measures   | Effectiveness indicators  |
|--|--|---|
| <p><b>Authors; article type; study period/ publication date; study design</b></p> <p><b>Country/ region; economy level</b></p> <p><b>Social distancing between individuals</b></p> <p><b>School measure/ closure</b></p> <p><b>Workplace measure/closure</b></p> <p><b>Public transport restriction</b></p> <p><b>Stay-at-home recommendation/ ordinances</b></p> <p><b>Others</b></p> | <p><b>Domestic travel restrictions:</b> a cordon sanitaire or public transportation closure</p> <p><b>Work from home, flexible working time and social distancing measures, closure of non-essential businesses</b></p> <p><b>School closure</b></p> | <p><b>Infectivity:</b> <math>R_t</math>, effective reduction number</p> <p><b>Incidence:</b> Incidence, incidence rate, attack rate, bed occupancy rate</p> <p><b>Mortality:</b> Mortality or fatality rate</p> <p><b>Effect time:</b> Action and effect duration, time of reaching peak</p> <p><b>Attendance:</b> Attendance % of location, daily vehicles miles, daily contact frequency, mobility of leaving home, travel distance</p> <p><b>(Infectivity):</b> There were contradictory results on <math>R_t</math> among the studies. Modelling showed strong association while other studies showed no impact unless other NPI was put in place, for example, physical distancing. It was difficult to relate observed changes in transmission dynamics to a single measure.</p> <p><b>(Incidence):</b> Observational data suggested that reopening schools has not been associated with significant increases in community transmission.</p> <p><b>(Infectivity):</b> There was a 40% <math>R_t</math> reduction by closing most of non-essential businesses while 31% by closing high risk businesses, for example, restaurant/bars/ nightclub/cinemas/gym.</p> |

ECDC, European Centre for Disease Prevention and Control; NPIs, non-pharmaceutical interventions; SAGE, Scientific Advisory Group for Emergencies.



of businesses. The SAGE report<sup>22</sup> suggested a moderate impact of work from home measure, with a reduction of  $R_t$  between 0.2 and 0.4. Brauner *et al*<sup>17</sup> estimated that a 29%  $R_t$  reduction was likely to follow with closing most of non-essential businesses, while closing high risk businesses, for example, 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 USA was associated with a drop in  $R_t$ .<sup>19</sup>

### Public transport restriction

Public transport restriction refers to suspension/limitation of intracity or intercity public transportation. The SAGE report<sup>22</sup> 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<sup>10</sup> 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  $R_t$  while other studies did not show any impact unless introduced with other NPIs such as social distancing and behavioural changes.<sup>11</sup> 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*<sup>25</sup> in the USA 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*,<sup>29</sup> 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*<sup>30</sup> 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<sup>31</sup> of 58 cities in China, also with a remarkable  $R_t$  reduction, at 54.3%, demonstrated 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*<sup>10</sup> 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 IRR 0.87, 95% CI 0.84 to 0.91). Similar declining incidence was observed when public transport closure was added (pooled IRR 0.85, 95% CI 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,<sup>4</sup> 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*<sup>32</sup> 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*<sup>33</sup> analysed 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*<sup>34</sup> 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 and Roberson<sup>23</sup> showed that the stay-at-home order in Florida of the USA, after the first month of implementation, resulted in a 74%–82% reduction in person-to-person encounters, 55% in visits to non-essential venues and 45% in overall distance travelled. After 2 months of implementing stay-at-home order, the average distance travelled within the state was also found to decrease by 25%–40%. Further, a modelling study of Brauner *et al*<sup>17</sup> 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 a SAGE report,<sup>22</sup> 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 analysed in a time series. Marschner<sup>35</sup> used Australia data to back-project that there would be a fivefold increase in total infections

if social distancing measures were delayed by 1 week. Consistently, in Du *et al*'s study,<sup>31</sup> a 1-day delay in implementing the first intervention was expected to prolong an outbreak by 2.41 days. However, earlier lockdown, simulated by Islam *et al*,<sup>10</sup> 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<sup>36</sup> tracked  $R_t$  temporally for 2 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 2 weeks before the 100th case and a week before detecting the first case, respectively.<sup>36</sup>

In addition, social distancing measures had a progressive control impact on the growth rates of daily confirmed cases, with Courtemanche *et al*<sup>37</sup> 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*<sup>38</sup> 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 USA and the UK, 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  $R_p$ , incidence and mortality, along with indirect indicators such as daily contact frequency and travel distance. Based on changes in  $R_p$ , 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.

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*<sup>10</sup> 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 to have the highest reduction in  $R_p$ , 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*<sup>39</sup> 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.<sup>38</sup> It could be demonstrated in the comparison between countries that the stronger the level of social distancing, the faster it took to reduce the number of daily confirmed cases.<sup>38</sup> Furthermore, high initial infection incidence due to late implementation of measures would reduce the effectiveness of measures.<sup>38</sup> 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<sup>40</sup> in examining the Social Distancing Index, 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<sup>41</sup> 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 UAI people were unlikely to follow social distancing measures. Furthermore, Islam's study<sup>10</sup> observed greater case reduction associated with those countries with a higher gross domestic product (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,

**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  |
|--|--|--|---|---|--|--|
| <b>Relative frequency and consistency of evidence*</b>   | Adequate   | Moderate   | Limited   | No  | Adequate   | Adequate   |
| <b>(Infectivity): <math>R_t</math>, effective reduction number</b>                                   | Physical distancing of 1 m or more could reduce the transmission risk by five times and the protective impact was double for every extra metre. <sup>16</sup> Estimated $R_t$ reduced by 36%, 28% and 12% when gatherings were limited to 10, 100 and 1000 people, respectively. <sup>17</sup> | In the US, school closure decreased COVID-19 incidence (adjusted relative change per week, -62%). <sup>24</sup> Observational data from a number of the EU countries suggested that reopening of schools was not associated with increase of community transmission. <sup>11</sup> In the USA, school closure decreased COVID-19-related mortality (-58%). <sup>24</sup> | Estimated 29% $R_t$ reduction by closing most of non-essential businesses while 20% by closing high risk businesses. <sup>17</sup> In the USA, a 50% decline in visits to nonessential businesses was associated with a 45% decline in $R_t$ (95% CI 43% to 49%). <sup>19</sup> | No difference in reduction in $R_t$ . <sup>10</sup> | In Mainland China excluding Hubei (province of Wuhan), $R_t$ dropped from 3.34 to 0.89. <sup>30</sup> In 58 cities of China, $R_t$ dropped by 54.3%. <sup>31</sup> | From data of 41 countries, estimated $R_t$ reduced by 10% by stay-at-home orders (-2%-22%). <sup>17</sup> UK estimation suggested that country lockdown could reduce $R_t$ from 2.7 to 0.6 while 2-3 weeks short stay-at-home order had moderate impact by reducing $R_t$ to below 1. <sup>22</sup> China $R_t$ reduced from 2.35 to 1.05 during the lockdown. <sup>49</sup> |
| <b>(Incidence): Infection incidence/ratio of incidence rate ratio/attack rate/bed occupancy rate</b> | In the USA, COVID-19 infection was less likely among the public who always practiced social distancing (aOR for indoor social distancing, 0.32 (95% CI 0.10 to 0.99); aOR for outdoor social distancing, 0.10(95% CI 0.03 to 0.33). <sup>20</sup>  | In the US, school closure decreased COVID-19 incidence (adjusted relative change per week, -62%). <sup>24</sup> Observational data from a number of the EU countries suggested that reopening of schools was not associated with increase of community transmission. <sup>11</sup>   |   |   | In the USA, mean daily COVID-19 case growth rate decreased by 0.9% per day 4 days after lockdown. <sup>25</sup>  | Data from 32 countries showed decreased incidence of COVID-19 (pooled incident rate ratio, IRR 0.87, 95% CI 0.84 to 0.91). <sup>10</sup> 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. <sup>37</sup>  |
| <b>(Mortality): Mortality/fatality rate</b>  |  |  |   |   |  |  |

Continued

Table 3 Continued

|  | Social distancing between individuals | School closure   | Workplace measures | Public transport restriction | Partial lockdown  | Full lockdown  |
|--|---------------------------------------|--|--------------------|------------------------------|---|--|
| <b>(Effect time): Action and effect duration/ time of reaching peak</b>  |                                       |  |                    |                              | In 58 cities of China, mean time until successful containment was 8 days. <sup>31</sup> |  |
| <b>(Attendance): Attendance % of location/daily vehicles miles/daily contact frequency/ mobility of leaving home/distance travel</b> |                                       | In Florida, the USA found that closing of schools resulted in a 40%–55% reduction in average distance travelled. <sup>23</sup> |                    |                              | In Spain, self-reported walking time decreased by 58.2%. <sup>46</sup>                  | 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. <sup>32</sup> Stay-at-home order in Florida of the USA resulted in a reduction of in-person encounters by 74%–82%, visits to nonessential venues by 55%, and overall distance travelled by 45%. <sup>23</sup> |

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

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<sup>22</sup> 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' behaviours. More empirical evidence focusing on the dynamic interaction of the environment, customer behaviours and transmission risks would be beneficial.

Some researchers proposed strategies need to be demonstrated by empirical evidence. A circuit breaker, proposed in the SAGE report,<sup>22</sup> referring to as the 2–3 weeks short-time lockdown, could put the epidemic curve back by about 28 days or more. Based on historical evidence from the 1918 influenza pandemic, Correia *et al*<sup>42</sup> argued that regions taking earlier and aggressive social distancing measures grew faster economically in the postpandemic 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*<sup>43</sup> 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, healthcare workers but also on the overall population. However, Kim and Su<sup>44</sup> 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 in compliance with social distancing mandates. Response measures should be proportional to the risk in different settings.

Our search period was up to 30 September 2020 when vaccine was not available for population use. For mass vaccination programmes which were implemented in most countries after December 2020.<sup>45</sup> The reported number of cases per population was under 2.3% across countries. Including unreported asymptomatic cases, population immunity should 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 publicised 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 referring 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 devices 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 (eg, 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 for 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 influenza, where a total elimination is not the goal. Fatigue of preventive behaviours 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 of self-protective 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.

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