COVID-19 Living Evidence Synthesis 20.1: Effectiveness of combinations of public health and social measures over time and across jurisdictions for reducing transmission of COVID-19 and other respiratory infections in non-healthcare community-based settings

Executive summary

Question

- What is the effectiveness of the combinations of at least two public health and social measures, or PHSMs (e.g., quarantine and isolation, masks, ventilation, physical distancing and reduction of contacts, hand hygiene and respiratory etiquette, and cleaning and disinfecting) in reducing transmission of COVID-19 and other respiratory illnesses (e.g., influenza and respiratory syncytial virus, or RSV) in non-healthcare community-based settings?

Background

- The assessment of the effectiveness of different PHSMs should consider and control for confounding due to the contemporaneous presence of other interventions and for correlations among them.
- There is variable effectiveness of PHSMs according to the social context, the country, the period of time analyzed, the wave of infection and pre-vaccination versus post-vaccination periods.

Key points

- We included 72 studies, of which 69 were observational studies and three were randomized trials.
- The judgment of risk of bias in randomized trials was low in two and with some concerns in one, and the judgement of risk of bias in observational studies was moderate in 26 studies, serious in 25, and critical in 18.
- Overall, 53 studies focused on the primary outcome (reduction of COVID-19 transmission), 14 on reducing COVID-19 deaths, seven on reducing transmission of other respiratory infectious diseases, and eight on negative outcomes.
- The three randomized trials showed that adhering to testing, wearing masks, cleaning, and good ventilation are effective in preventing transmission of COVID-19 in public gatherings.
- The observational studies found that combinations of PHSMs have stronger effects in reducing transmission when more PHSMs were combined, and when stricter measures of gathering restrictions or physical distancing were included.
- Three PHSMs were found to have moderate to strong effects in reducing COVID-19 transmission: mask-wearing (16/17 studies), gathering restrictions (18/19 studies), and business closures (8/9 studies).
- Four PHSMs were found to have weak to moderate effects in reducing COVID-19 transmission: work-from-home/workplace closures (14/14 studies), international travel restrictions (9/13 studies), public transport bans (5/7 studies), and domestic travel restrictions (3/5 studies).
- Two PHSMs were found to have an effect on reducing COVID-19 transmission, but with effectiveness varying from weak to strong: lockdown/stay-at-home orders (20/22 studies) and school closures (15/18 studies).
- Regarding the 'stringency index', the eight studies with the most reliable evidence found that increases in the stringency index were associated with stronger effects on reducing the case growth rate or the Rt number.
- Three studies with serious risk of bias found a strong significant protective effect of school closures with bronchiolitis cases, RSV activity, and influenza.
- Two studies found an association between social-gatherings restrictions, school closures, and contact-tracing strategies with negative impacts on mental well-being or increases in anxiety and depression, especially among women.

Suggested Tweet

- Combinations of #publichealth and social measures found to have stronger effects in reducing #COVID19 transmission when more measures were combined, and when stricter measures of gathering restrictions or physical distancing were included

Date of last literature search: 3 March 2023

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Please note: This living evidence synthesis (LESs) is part of a suite of LESs of the best-available evidence about the effectiveness of six PHSMs (masks, quarantine and isolation, ventilation, physical distancing and reduction of contacts, hand hygiene and respiratory etiquette, cleaning, and disinfecting), as well as combinations of and adherence to these measures, in preventing transmission of COVID-19 and other respiratory infectious diseases in non-health care community- based setting. This first full version was developed after two interim versions, which are available upon request. The next update to this and other LESs in the series is to be determined, but the most up-to-date versions in the suite are available on the COVID-END website. We provide context for synthesizing evidence about public health and social measures in Box 1 and an overview of our approach in Box 2.

Box 1: Context for synthesizing evidence about public health and social measures (PHSMs)

This series of living evidence syntheses was commissioned to understand the effects of PHSMs during a global pandemic to inform current and future use of PHSMs.

General considerations for identifying, appraising and synthesizing evidence about PHSMs

- PHSMs are population-level interventions and typically evaluated in observational studies.
  - Many PHSMs are interventions implemented at a population level, rather than at the level of individuals or clusters of individuals such as in clinical interventions.
  - Since it is typically not feasible and/or ethical to randomly allocate entire populations to different interventions, the effects of PHSMs are commonly evaluated using observational study designs that evaluate PHSMs in real-word settings.
  - As a result, a lack of evidence from RCTs does not necessarily mean the available evidence in this series of LESs is weak.
- Instruments for appraising the risk of bias in observational studies have been developed; however, rigorously tested and validated instruments are only available for clinical interventions.
  - Such instruments generally indicate that a study has less risk of bias when it was possible to directly assess outcomes and control for potential confounders for individual study participants.
  - Studies assessing PHSMs at the population level are not able to provide such assessments for all relevant individual-level variables that could affect outcomes, and therefore cannot be classified as low risk of bias.
- Given feasibility considerations related to synthesizing evidence in a timely manner to inform decision-making for PHSMs during a global pandemic, highly focused research questions and inclusion criteria for literature searches were required.
  - As a result, we acknowledge that this series of living evidence syntheses – about the effectiveness of specific PHSMs (i.e., quarantine and isolation; mask use, including unintended consequences; ventilation, reduction of contacts, physical distancing, hand hygiene and cleaning and disinfecting measures), interventions that promote adherence to PHSMs, and the effectiveness of combinations of PHSMs – does not incorporate all existing relevant evidence on PHSMs.
  - Ongoing work on this suite of products will allow us to broaden the scope of this review for a more comprehensive understanding of the effectiveness of PHSMs.
  - Decision-making with the best available evidence requires synthesizing findings from studies conducted in real-world settings (e.g., with people affected by misinformation, different levels of adherence to an intervention, different definitions and uses of the interventions, and in different stages of the pandemic, such as before and after availability of COVID-19 vaccines).

Our approach to presenting findings with an appraisal of risk of bias (ROB) of included studies

To ensure we used robust methods to identify, appraise and synthesize findings and to provide clear messages about the effects of different PHSMs, we:

- acknowledge that a lack of evidence from RCTs does not mean the evidence available is weak

- assessed included studies for ROB using the approach described in the methods box
- typically introduce the ROB assessments only once early in the document if they are consistent across sub-questions, sub-groups and outcomes, and provide insight about the reasons for the ROB assessment findings (e.g., confounding with other complementary PHSMs) and sources of additional insights (e.g., findings from LES 20 in this series that evaluates combinations of PHSMs)
- note where there are lower levels of ROB where appropriate
- note where it is likely that risk of bias (e.g., confounding variables) may reduce the strength of association with a PHSM and an outcome from the included studies
- identify when little evidence was found and when it was likely due to literature search criteria that prioritized RCTs over observational studies.

Implications for synthesizing evidence about PHSMs

Despite the ROB for studies conducted at the population level that are identified in studies in this LES and others in the series, they provide the best-available evidence about the effects of interventions in real life. Moreover, ROB (and GRADE, which was not used for this series of LESs) were designed for clinical programs, services and products, and there is an ongoing need to identify whether and how such assessments and the communication of such assessments, need to be adjusted for public-health programs, services and measures and for health-system arrangements.

Findings

After removing duplicates, we screened 3,494 titles and abstracts, and reviewed 239 potentially relevant full-text documents. After excluding 160 studies (see Appendix 7 for a list of studies excluded in this final step), 72 full-text documents were included (see Appendix 2 for a list of studies included). Overall, we included 44 studies with a multi-country scope (i.e., presenting findings from three or more countries), and 28 studies focused on a single country comparing different jurisdictions (Australia n=2, Canada n=1, China n=3, France n=1, India n=2, Ireland n=1, Japan n=2, Mexico n=1, Norway n=1, Oman n=1, South Korea n=2, Spain n=2, Switzerland n=1, Taiwan n=1, U.S. n=7). Study selection is summarized in Figure 1 (PRISMA chart).

Of the 72 included studies, 53 focused on the primary outcome (reduction of COVID-19 transmission). For secondary outcomes, eight focused on reducing transmission of other respiratory infectious diseases (RIDs), 15 on reducing COVID-19 deaths, and eight on negative outcomes (six on mental well-being, one on excess mortality, and one on effects over the HIV care continuum).

We included three randomized studies, two with a low risk of bias and one with some concerns. Among the observational studies, 26 had a moderate risk of bias, 25 serious, and 18 had a critical risk of bias. (see Appendix 4 for the assessment of risk-of-bias of articles included in the synthesis).

Summary of findings about the primary outcome: Reducing transmission of COVID-19

We included three randomized trials, two with a low risk of bias (24; 25) and one with some concerns.(26) Studies showed that adhering to testing, wearing masks, cleaning and good ventilation was effective in preventing transmission of COVID-19 in public gatherings.(24-26)

We also included 53 observational studies for the primary outcome. The risk of bias was moderate in 21 studies, serious in 17, and critical in 15. The

Box 2: Our approach

We retrieved candidate studies by searching: 1) PubMed via COVID-19+ Evidence Alerts; 2) pre-print servers; and 3) ClinicalTrials.gov. Searches were conducted for studies reported in English, conducted with humans and published since 1 January 2020 (to coincide with the emergence of COVID-19 as a global pandemic). Our detailed search strategy is included in **Appendix 1**.

Studies were identified up to eight days before the version release date. Studies that report on empirical data with a comparator were considered for inclusion, with modelling studies, simulation studies, cross-sectional studies, case reports, case series, and press releases excluded. Other study designs may be considered for future versions in the absence of other forms of evidence. A full list of included .studies is provided in **Appendices 2-5**. Studies excluded at the last stages of reviewing are provided in **Appendix 7**.

Population of interest: All population groups that report data related to all COVID-19 variants and sub-variants.

Intervention and control/comparator: a combination of at least two PHSMs (e.g., quarantine, isolation, contact tracing, masks, ventilation, physical distancing, reduction of contacts, lockdowns, online schooling, work-from-home policies, hand hygiene and respiratory etiquette, and cleaning and disinfecting) compared to no PHSMs, other PHSMs or combination of PHSMs, or a less intensely applied combinations of PHSMs.

Primary outcome: Reduction in transmission of COVID-19

Secondary outcomes: Any studies, regardless of whether they included the primary outcome, that reported a reduction in COVID-19-associated ICU admission, ventilation and deaths, and transmission of other respiratory infections.

Data extraction: Data extraction was conducted by one team member and checked for accuracy and consistency by another using the template provided in **Appendix 8**.

Critical appraisal: The risk of bias (ROB) of individual studies was be assessed using validated ROB tools. For randomized controlled trials, we used ROB-2, and for observational studies, we used ROBINS-I. Judgements for the domains within these tools were decided by consensus within synthesis team and undergo revision with subsequent iterations of the LES as needed. Additional ROB tools will be added as needed to fit with other study designs. Once a study was seemed to meet one criterion that made it 'critical' risk of bias, it was dropped without completing the full ROB assessment. Our detailed approach to critical appraisal is provided in **Appendix 9**. Additional details about the approach to critical appraisal are provided here.

Summaries: We summarized the evidence by presenting narrative evidence profiles across studies by outcome measure. Future versions may include statistical pooling of results if deemed appropriate.

The next update to this document is to be determined.

characteristics, findings, and assessment of risk of bias for each study are presented in Appendix 2a. The findings of all studies were summarized according to the period of time covered by the study (i.e., only the first half of 2020, all or most of 2020, all or most of 2020 and 2021), the country focus (multi-country or single country), and the risk of bias of observational studies (i.e., moderate, serious and critical). See Table 3 for this summary of findings.

Eleven studies analyzed the stringency index. The risk of bias was moderate in four studies,(1-4) serious in three,(5-7) and critical in three.(8-10) All studies found a significant effect on reducing the case growth rate or the reproduction number (Rt). Increases in the stringency index were associated with stronger effects.(1-10) Overall, specific combinations of two,(11-13) three,(11; 12; 14; 15) four,(11; 12; 16; 17) and more than four PHSMs (1; 4; 18-23) had stronger effects on reducing transmission when more PHSMs were combined, and when stricter measures of gathering restrictions or physical distancing were included in the combination.(1; 4; 11-23) See Table 1 for further information about stringency index effectiveness.

The most common PHSMs assessed in the studies synthesized were stay-at-home policies/lockdowns (n=36), school closures (n= 34), restrictions on gatherings (n=34), restrictions on internal movements (n=29), work-from-home/workplace closures (n=23), international travel restrictions (n=23), mask mandates (n=22), non-essential business closure (n=20), closures of public transport (n=17), cancellation of public events (n= 18), the stringency index (composed by ten PHSMs) (n=11), and contact tracing (n=11). Figure 2 summarizes the number of studies assessing each PHSM by outcome.

Three PHSMs were found to have moderate to strong effects in reducing COVID-19 transmission: mask mandate/requirement (16/17 studies), gathering restrictions (18/19 studies), and business closures (8/9 studies). Mask mandates/requirements were identified in 13 multi-country and four single-country studies. Among the eight studies with the most reliable evidence, three indicated that this intervention was the most effective,(18; 27; 28) and four indicated that was one of the most effective PHSMs.(4; 11; 20; 29; 30) The effect on reducing transmission ranged between 8.8% and 71% (higher with stricter implementation), with only one study reporting no effect.(31) Gathering restrictions were identified in 17 multi-country and two single-country studies. The nine most reliable studies found an effect on reducing COVID-19 transmission that was higher when the intervention was stricter.(2; 4; 12; 18; 28-30; 32) For instance, studies only covering the first half of 2020 reported that limiting gatherings to less than: 1) 1,000 people had an effect of 23% to 37% reduction in COVID-19 transmission; 2) 100 people had effects ranging from 18% to 34%; and 3) 10 people had effects ranging from 9% to 42%. Lastly, business closures were identified in five multi-country and four single-country studies. Among the five studies with the most reliable evidence,(4; 12; 29; 32; 33) four found this PHSM effective in reducing COVID-19 transmission.(4; 12; 32; 33) Studies that covered most of 2020 and 2021 reported a significant effect on reducing transmission during the second wave of infections (35%).(4; 9)

Four PHSMs were found to have weak to moderate effect in reducing COVID-19 transmission: work-from-home/workplace closures (14/14 studies), international travel restrictions (9/13 studies), public transport bans (5/7 studies), and domestic travel restriction (3/5 studies). Work-from-home/workplace closures were identified in 13 multi-country and one single-country studies. The six studies with the most reliable evidence,(2; 18; 20; 28; 34; 35) found this PHSM effective in reducing COVID-19 transmission. Most studies covering only the first half of 2020 reported an effect varying between 1% to 15%, all studies covering most or all of 2020 reported an effect of 4.5% to 10%, and studies covering most of 2020 and 2021 reported an effect of 28% in the first two waves that declined to 9.7% in the third wave. International travel restrictions were identified in 12 multi-country and one single-country study. The five studies with the most reliable evidence,(2; 18; 27; 35; 36) found this intervention effective principally in the pre-vaccination period. Lastly, public transport bans were identified in seven multi-country studies. Among the three studies with the most reliable evidence,(2; 18; 27) two found negligible effects and one covering the first half of 2020 found a moderate effect.

Two PHSMs - lockdowns/stay-at-home orders (20/22 studies), and school closures (15/18 studies) - were found to have an effect on reducing COVID-19 transmission, but with effectiveness varying from weak to strong. Lockdowns/stay-at-home orders (used indistinctly in different studies) were identified in 16 multi-country and six single-country studies. In addition to the effects of other interventions already in place, lockdowns/stay-at-home orders were found to be effective in reducing the transmission of COVID-19 (varying from 3% to 52%). Among the seven studies with the most reliable evidence, two multi-country studies found a negligible effect on COVID-19 transmission, and five found different levels of effectiveness.(2; 4; 12; 29; 30; 34; 35) School closures were identified in 14 multi-country and four single-country studies. Among the nine studies with the most reliable evidence,(4; 12; 18; 20; 27-29; 35; 37) four reported a strong effect in reducing transmission (12-38%), two reported some effect, two found a negligible or no effect, and one study found that in the post-vaccination period, school closure increased the COVID-19 transmission. Only one study disaggregated the effect of closing universities and schools, and found the closure of universities to be more effective than the closure of schools at secondary, primary, or preschool levels.(23)

Other PHSMs such as domestic travel restrictions,(5; 15; 38) quarantine,(11; 39) contact tracing,(39) isolation policies,(39) testing of only symptomatic people,(13; 27; 28; 39) and public-information campaigns,(40; 41) were found to have weak or negligible effectiveness in reducing COVID-19 transmission (see Table 2 and Table 4 for further information about all PHSMs identified).

Summary of findings about secondary outcome 1: Reducing COVID-19 ICU admission, ventilation and deaths

We included 15 studies reporting on reduction of COVID-19 related deaths. The risk of bias was moderate in six studies, serious in five, and critical in four. The characteristics, findings and assessment of risk of bias for each study is presented in Appendix 2b.

The most common PHSMs assessed in the studies synthesized were stay-at-home policies/lockdowns (n=5), school closures (n= 5), mask mandates (n=5), non-essential business closure (n=4), restrictions on gatherings (n=3), restrictions on internal movements (n=3), work-from-home/workplace closures (n=3), contact tracing (n=3), international travel restrictions (n=2), and the stringency index (n=2). Figure 2 summarizes the number of studies assessing each PHSM by outcome.

Among the studies with the most reliable evidence, gathering restrictions was consistently associated with reductions in mortality in three multi-country studies,(29; 42; 43) as well as business closures, which showed a significant association with reduction of deaths in two multi-country studies.(29; 42) Three studies, two performed in the U.S. (45; 46) and one in India,(49) also showed a decrease in case fatality rate. Other PHSMs showed contradictory or inconsistent findings. Stay-at-home/lockdown orders showed conflicting findings, with two multi-country studies finding a non-significant tentative change in trend of deaths,(42; 43) while one multi-country study found an inverted U-quadratic effect, with an initial rise of deaths up to day 20 of the intervention followed by a decrease.(29) Regarding school closures, two multi-country studies found negative and statistically significant associations with reductions of deaths,(29; 43) while another multi-country study found a negative but non-significant effect.(42) Work from home policies were associated with lower COVID-19 mortality rates in one multi-country study,(43) and no effects in another multi-country study.(42) International travel restrictions showed contradictory findings, with two multi-country studies finding no significant effect (42) or only a marginal effect when the strictness of the measure was considered.(43) One study in India reported that the stringency index was not significant predictor of COVID-19 mortality.(50)

Other PHSMs were found to have no effect or not statistically significant effects.(29; 32; 42; 47) Table 2 and Table 5 provide further information about all PHSMs identified.

Summary of findings about secondary outcome 2: Reducing transmission of other respiratory infections

We included eight studies that report on reducing transmission of other respiratory infections as an outcome. The risk of bias was moderate in two studies, serious in three, and critical in three. The characteristics, findings and assessment of risk of bias for each study is presented in Appendix 2c.

We only identified studies reporting findings on seven PHSMs (i.e., school closures, mask mandates, workplace closures, stay-at-home/lockdowns, public transport bans, domestic travel restrictions, and physical distancing). Three multi-country studies reported a strong significant protective effect of school closures with bronchiolitis,(51) RSV activity,(52) and influenza.(53) One multi-country study reported an association of mask mandates and workplace closure with a reduced bronchiolitis caseload.(51) One multi-country study found an association of public transport bans and domestic travel restrictions with reductions of RSV infections.(52) Stay-at-home/lockdowns were found to be associated with a reduced bronchiolitis caseload (51) and a reduction of RSV activity.(52) Table 2 and Table 6 provide further information about all PHSMs identified. Three studies that assessed several PHSMs as a package, two performed in South Korea (54; 55) and the other in China,(56), found a reduction in number of patients treated for respiratory diseases, emergency admission and hospitalizations due to pneumonia, bronchitis, bronchiolitis, and acute upper respiratory infections (AURI).

Summary of findings about negative outcomes of the combination of PHSMs

We included eight studies that report on negative outcomes of implementing PHSMs. The risk of bias was moderate in three studies and serious in five. The characteristics, findings and assessment of risk of bias for each study are presented in Appendix 2d.

One multi-country study found an association between social-gatherings restrictions and contact-tracing strategies and negative effects on mental wellbeing, which was more pronounced in women, those with non-tertiary education, those aged 18-29 or 30-44, those not living with a partner, those living with children aged under 12 years, and those living with children between 12 and 17 years.(57) One multi-country study found associations of anxiety and depressive symptoms with stay-at-home requirements and international travel restrictions (stronger among males); and with gathering restrictions, school closures, cancelling public events, and domestic travel restrictions (stronger among females).(58)

We included four studies performed in China,(59) Australia,(60) the U.S.,(61) Peru and the Netherlands.(62) Table 2 and Table 7 provide further information about all PHSMs identified. The Australian study reported a small but statistically significant effect of lockdown on MHI-5 scores, with greater decline for residents of Victoria in 2020 (exposed earlier to the lockdown) than for those in the rest of Australia.(60) Stratified analyses showed that the lockdown effect was larger for females than for males, and even larger for women in couples with children younger than 15 years, and for females who lived in flats or apartments or semi-detached houses, terraced houses, or townhouses.(60) The study from the U.S. found that in regions with lockdowns, the usage of mental health services increased more than in regions without it, and that patients diagnosed with panic disorders and reaction to severe stress were significantly more affected by the lockdowns.(61) The study from China found that PHSMs were associated with a decrease in post-exposure prophylaxis prescriptions for protecting people at risk for HIV, decrease in HIV tests, decrease in HIV diagnoses and decrease in CD4 counts in the first week during implementation of a package of PHSMs.(59) The study in Peru and the Netherlands found an increase in depression symptoms for adolescents 9-18 years of age that lived in regions with higher levels of government restrictions.(62)

Table 1: Principal findings of PHSMs integrated to the stringency index or into explicit combinations

PHSM combination	Outcome	Risk of bias of studies	Principal findings
Stringency index	Reducing transmission of COVID-19	Moderate (n=4) (1-4)	• The high-intensity of PHSMs (>80th percentile of the stringency index) was associated with the decrease in the case growth rate, especially with seven days of duration [RR = 0.93, 95% CI: 0.89-0.98], and 21 days of duration [RR = 0.95, 95% CI: 0.91-1.00] (1) • The most stringent set of PHSMs implemented in each region reduced Rt by an average of 56% [95% CI: 40-64%], compared to 76-82% in the first wave, even though PHSMs in the second wave were often similarly strict or stricter (4) • Countries with more stringent measures tend to have lower Rt on average; no country with a stringency index lower than 50 could bring average Rt to below one within two weeks (2) o Countries with Rt less than 1.5 on the date of the 100th case have generally kept total cases at a manageable level (as of May 28, 2020), with the exceptions of Peru and Russia, despite early lockdowns (2) o The estimated coefficient of the stringency index was negative and significant, meaning that an increase in the index by 10 points reduced Rt by 0.06 [95% CI:-0.08, -0.04] (2) • Under a practical vaccination rate between 20% and 30%, vaccines reduced Rt in populations by a median of 18%, while PHSMs alone could reduce Rt by 40% during the same period (3) o When the practical vaccination rate reached 40%-50%, the effect of vaccination (28%) surpassed that of PHSMs (25%) (3) o When the practical vaccination rate exceeded 30%, PHSMs with similar stringency appeared to have less impact on COVID-19 transmission (3)
		Serious (n=4) (5-7; 50)	• The stringency index was negative and significant (β = -0.0043, t = -0.22) after controlling for several factors, implying that for one standard deviation increase in the stringency index the COVID-19 spread rate decreases approximately by 10.27% (5) • From January 2020 to July 2020, each additional week between the country's first case and reaching SI greater than 40 resulted in an average growth rate of cases higher by a factor of 1.93 (6) • The stringency index in phase 1 had a coefficient of 0.39 (SE 0.30), in Phase 2 of -9.55 (SE 1.91) ($p< 0.001$), and in Phase 3 of -18.43 (SE 5.41) ($p< 0.001$); meaning that the stringency index did not have a significant influence at the beginning of the pandemic but turned out to be significant and inversely related to daily new cases during Phases 2 and 3 (7) • The stringency index was not significant predictor of COVID-19 morbidity (50)
		Critical (n=3) (8-10)	• Classifying PHSMs in four levels of stringency (e.g., level one being the lowest stringency) showed that in Taiwan (beginning in level 1 with Rt of 2.85) the implementation of level 2 measures decreased the mean Rt to 2.40 (95% CI 1.99-2.86), and level 3 measures further decreased the mean Rt value to 1.59 (95% CI 1.30-1.90)

			• Only after level 3 measures were expanded to all of Taiwan did the mean Rt decrease to below 1 (0.86 [95% CI 0.76-0.95]), which then dropped even further when those measures were strengthened by prohibiting dine-in services and setting up a work-from-home order (0.65 [95% CI 0.57-0.74]) (8) • In Spain, the Rt showed a decrease of 0.17 (95% CI: 0.11-0.23), 0.18 (95% CI: 0.13-0.23) and 0.12 (95% CI: 0.07-0.17) units per SI unit respectively for a one-week, two-week and three-week delay in the observations (9) • There was a moderate, inverse semi-partial correlation (p= -0.50) between the cumulative incidence of COVID-19 cases (average ± SD: 225.91 ± 173.95 per 100,000) and cumulative containment health index (cCHI) accumulated over the pre-epidemic period (176.11 ± 230.08), whilst controlling for population density (130.99 ± 100.98 km2), which was statistically significant (p adjusted = 0.0247) (10) o Early adoption of stringent containment measures prior to detection of the first confirmed case, together with ramping up containment stringency during the early days of epidemics, was associated with a lower disease occurrence (10) o The delayed adoption of stringent containment measures did not fully compensate for the lack of early response (10)
	Reducing transmission of other RIDs	Moderate	None identified
		Serious (n=2) (52; 53)	• The stringency index was negatively and significantly associated with the difference in Respiratory Syncytial Virus (RSV) activity; a 10-point decrease in the stringency index was associated with an average absolute increase in the difference between observed and expected RSV positivity rate of 0.8% (52) • The stringency index was borderline associated with a decreased risk of having an influenza season; for each one-point increase in the stringency index, the risk of having an influenza season decreased by 2% [IRR: 0.98, 95% CI: 0.96-1, p = 0.02] (53)
		Critical	None identified
	Reducing hospitalizations, admission ICU, deaths	Moderate	None identified
		Serious (n=1) (50)	• The stringency index was not significant predictor of COVID-19 mortality (50)
		Critical	None identified
	Negative effects	Moderate (n=2) (58; 63)	• Controlling for individual and contextual variables, higher policy stringency was associated with higher mean psychological distress scores and lower life evaluations, standardized coefficients β=0·014 [95% CI 0·005 to 0·023] for psychological distress; β =-0·010 [-0·015 to -0·004] for life evaluation (63) • For each ten-point increase in government response stringency, the odds of reporting anxiety symptoms increased by 1.4% [OR=1.014, 95% CI=1.008-1.019], and the odds of reporting depressive symptoms increased by 2.7% [OR=1.027, 95% CI=1.022-1.032] (58)
		Serious	None identified
		Critical	None identified
Any combination of two PHSMs	Reducing transmission of COVID-19	Moderate (n=2) (11; 12)	• Restrictions of gathering to less than 1,000 and school and universities closure reduced the Rt by 52.4%, the combination of gathering to less than 1,000 with some businesses closed reduced the Rt by 37%, and with most business closed the effect increased to 43.6% (12)

			○ Restrictions of gatherings to less than 100 and school and universities closure reduced the Rt by 59.5%, the combination of gathering less than 100 with some businesses closed reduced the Rt by 46.4%, and with most business closed the effect increased to 52.4% (12) ○ Restrictions of gathering to less than 10 and school and universities closure reduced the Rt by 64.3%, the combination of gathering less than 10 with some businesses closed reduced the Rt by 52.7%, and with most business closed the effect increased to 57.7% (12) • Any two types of combination of PHSMs had the following effects in reducing the Rt number (11) ○ Physical distancing + mandatory mask, 53.30% (-2.50 to 41.03) p=0.064 ○ Physical distancing + quarantine, -38.58% (-44.23 to -32.37) p<0.001 ○ Traffic + mandatory mask, -66.58% (-92.67 to 52.41) p=0.157 ○ Traffic + quarantine, -17.83% (-20.07 to -15.53) p<0.001 ○ Traffic + physical distancing, -44.11% (-46.37 to -41.76) p<0.001
		Serious	None identified
		Critical (n=1) (13)	• Under both any effort and maximum effort scenarios, there is strong evidence for the association between two of the 13 PHSMs assessed (i.e., school closure and internal movement restrictions) and reductions of Rt (13)
	Reducing transmission of other RIDs	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Reducing hospitalizations, admission ICU, deaths	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Negative effects	Moderate	None identified
		Serious	None identified
		Critical	None identified
Any combination of three PHSMs	Reducing transmission of COVID-19	Moderate (n=4) (11; 12; 14; 15)	• Restrictions of gathering to less than 1,000, school and universities closure, and some business closed reduced the Rt by 60.9%, and combining with most businesses closed increased the effect to 65.1% (12) ○ Restrictions of gathering to less than 100, school and universities closure, and some business closed reduced the Rt by 66.9%, and combining with most businesses closed increased the effect to 70.4% (12) ○ Restrictions of gathering to less than 10, school and universities closure, and some business closed reduced the Rt by 70.8%, and combining with most business closed increased the effect to 73.9% (12) • Any three types of combination of PHSMs had the following effects in reducing the Rt number (11) ○ Physical distancing + quarantine + mandatory mask: -69.73% (-82.48 to -47.69) p<0.001 ○ Traffic + quarantine + mandatory mask: -17.06% (-24.99 to -8.29) p<0.001 ○ Traffic + physical distancing + mandatory mask: -54.32% (-79.59 to 2.24) p=0.057

			○ Traffic + physical distancing + quarantine: -54.12% (-55.63 to -52.56) p<0.001 • In the U.S., one study found for the country as a whole, that only duration of policy level 4 (combination of sheltering in place/stay-at-home, public mask requirements, or travel restrictions) achieved statistical significance to increase doubling times for transmission (14) ○ Each day on intervention level 4 was associated with an increase in log beta doubling time of 0.02 (95% CI: 0.01-0.03, p < 0.0001) (14) ○ When calculating the predicted doubling time from the data, level 4 policies achieve a peak 40 days after initiation with an estimated doubling time of 24 days (95% CI, 19.1-29.5) compared to 23 days after initiation of level 3 (non-essential business closures, suspending non-violent arrests, suspending elective medical procedures, suspending evictions, or restricting mass gatherings of at least 10 people) policies for an estimated doubling time of 17.6 days (95% CI, 14.5-22.3) (14) ○ Levels 1 (governor declaration of a State of Emergency) and 2 (school closures, restricting access/visits to nursing homes, or closing restaurants and bars) never achieved increased doubling times (14) ○ For the country as a whole, the analysis indicated that, under conditions of high policy compliance (scaled value of 8), intervention level 4 achieved a 50% reduction in COVID-19 case rates in 16 days (95% CI for 16-day case reduction: 40.2-61.8%), compared to 22 days for intervention level 3 (95% CI: 35.1-71.5%) (14) • In China, one study found that cities that implemented a Level 1 response (any combination of three PHSMs) preemptively, before discovering any COVID-19 cases, reported 33.3% (95% CI, 11.1 to 44.4%) fewer laboratory-confirmed cases during the first week of their outbreaks (13.0 cases; 95% CI, 7.1 to 18.8, n = 125 cities) compared with cities that started control later (20.6 cases, 95% CI, 14.5 to 26.8, n = 171 cities), with a statistically significant difference between the two groups (Mann-Whitney U =8197, z = 3.4, P < 0.01) (15)
		Serious	None identified
		Critical (n=1) (64)	• In Australia, one study suggested that it took much longer for the combination of mask-wearing, lockdown and border closure to affect new case numbers in Victoria (64)
	Reducing transmission of other RIDs	Moderate	None identified
		Serious	None identified
		Critical (n=1) (54)	• In South Korea, one study found that patients treated for respiratory diseases nationwide declined significantly each day, by 53.18 per 10 000 inhabitants (95% CI -65.86 to -40.49) compared with that before implementation of (mask mandate, physical distancing, and hand hygiene) (54)
	Reducing hospitalizations, admission ICU, deaths	Moderate (n=2) (14; 47)	• In Switzerland, one study found that compared to implementing none of the policies (i.e., neither face-mask mandates, contact tracing, nor social distancing rules), this combination resulted in an estimated decrease in all-cause mortality of 5.1% (95% CI: -7.9% to -2.4%) (47) • In the U.S., one study found that for the country as a whole, duration of policy levels 3 (non-essential business closures,

			suspending non-violent arrests, suspending elective medical procedures, suspending evictions, or restricting mass gatherings of at least 10 people) and 4 (sheltering in place/stay-at-home, public mask requirements, or travel restrictions) were both significantly associated with higher death rates; however, the distribution of deaths indicate potential heterogeneity (14) o Level 3 policies in places with high levels of compliance resulted in significantly lower death rates that low levels of compliance (14)
		Serious	None identified
		Critical	None identified
	Negative effects	Moderate	None identified
		Serious	None identified
		Critical	None identified
Any combination of four PHSMs	Reducing transmission of COVID-19	Moderate (n=2) (11; 12)	• Gatherings less than 1,000, school and universities closure, most businesses closure, and stay-at-home order were able to reduce the Rt to 0.99 [95% PI 0.638, 1.519], meaning a 69.9% reduction of the Rt (12) o Gatherings less than 100, school and universities closure, most businesses closure, and stay-at-home order were able to reduce the Rt to 0.87 [95% PI 0.510, 1.069], meaning a 72.3% reduction of the Rt (12) o Gatherings less than 10, school and universities closure, most businesses closure, and stay-at-home order were able to reduce the Rt to 0.75 [95% PI 0.510, 1.069], meaning a 77.3% reduction of the Rt [67-85%] (12) • The combination of these four types of PHSMs (traffic + distancing + quarantine + mandatory mask) reduced the Rt number by 62.81% (from -66.27 to -58.98) $p<0.001$ (11)
		Serious (n=2) (16; 17)	• During the first wave, restrictions on mobility, public transport, public events, and public spaces (Combination 1), and healthcare system improvements, border closures and restrictions to public institutions (Combination 2) reduced COVID-19 incidence after 28 and 35-days; mask policies reduced COVID-19 incidence (except after 35-days) (16) o During wave 2, restrictions on mobility, public transport and healthcare system improvements decreased COVID-19 cases and deaths across all countries, while border closures and restrictions to public institutions and mask policies showed inconsistent effects (16) • In the U.S., one study found that interventions that included school and leisure activity closure and nursing home visiting bans were all associated with an effective basic reproductive number (Reff) below one when combined with either stay at home orders (median Reff 0.97, 95% CI 0.58-1.39) or face masks (median Reff 0.97, 95% CI 0.58-1.39) (17) o Inclusion of more interventions further reduced Reff, with a minimum median Reff of 0.50 (0.30, 0.86) when all interventions were in place (17)
		Critical	None identified
	Reducing transmission of other RIDs	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Reducing hospitalizations,	Moderate	None identified
		Serious	None identified
		Critical	None identified

	admission ICU, deaths		
	Negative effects	Moderate	None identified
		Serious	None identified
		Critical	None identified
Any combination of more than four PHSMs	Reducing transmission of COVID-19	Moderate (n=4) (1; 4; 18; 20)	• The overall synergistic effect of six PHSMs (gatherings restrictions, masks, school closure, workplace closure, public transport closure, and movement restrictions) reached 92.3% [IQR: 88.1-96.9%] and declined with the epidemic process, changing from 95.4% in the first wave to 56.0% in the third wave, at the global level (18) • The combined effect of six PHSMs (gatherings restrictions, masks, school closure, workplace closure, public transport closure, and movement restrictions) declined from 83.3% in the first wave to 58.7% in the third wave, at the U.S. national level, while it had fluctuating performance across waves on regional and subnational scales (18) • In the second wave, all 17 PHSMs together reduced Rt by 66% [95% CI: 61-69%], compared to median reductions of 77-82% in the first wave (4) • The average main effect of ten PHSMs combined for case growth rate was gradually decreased with the increase in vaccine coverage (0%, 10%, 20%) under strict PHSMs (RR rose from 0.87 to 0.90 and then to 0.92) (1) • Closing schools, issuing face mask U.S.ge, and work-from-home mandates caused a persistent reduction on Rt after their initiation, which was not observed with the other social distancing measures (20)
		Serious (n=2) (21; 22)	• In Oman, there was a sharp drop in Rt from 3.7 (95% confidence interval [CI] 2.8-4.6) in mid-March to 1.4 (95% CI 1.2-1.7) in late March in response to the package of PHSMs, the response to more stringent PHSMs reduced Rt to 1.09 (95% CI 0.84-1.3) by the end of March (21) • In Japan, the relative reduction in Rt values after voluntary combination of PHSMs implementation (not to sell alcoholic beverages and shortened business hours for restaurants at night; closure of public facilities where large gatherings of people could be expected; stay-at-home measures, combined with domestic travel restrictions; school closures; banning public events; requests to not engage in free movement within a city/ward) was estimated to range from -110.9% to 43.0%, where negative values represent a failure to reduce the Rt value (22) • In Japan, when voluntary PHSMs were implemented in 16 prefectures, the Rt was reduced to<1 in only six of these prefectures, with the average relative reduction ranging from 2 to 19% (22)
		Critical (n=2) (19; 23)	• The combined effects of all PHSMs were negative and significant in 9 out of 10 countries, where their combined effects ranged from -0.10 (95% CI: -0.06 to -0.13) in England to -0.33 (95% CI: -0.09 to -0.57) in South Korea (19) • The combination of 13 PHSMs implemented across Europe had a high efficiency at reducing transmission rates, with a median reduction of 71% (interquartile range of 58-81%) (23)
		Moderate	None identified

	Reducing transmission of other RIDs	Serious (n=1) (56)	• The reduction in admission numbers following PHSMs was -55.0% (-57.9 to -51.9%) for all-cause respiratory diseases, -62.7% (-65.7 to -59.5%) for pneumonia, -48.1% (-53.3 to -42.3%) for bronchitis & bronchiolitis, and -24.3% (-28.6 to -19.8%) for AURI (56) o Stratification analysis showed the reduction was most drastic for children at 4-6 and 7-12 years (56)
		Critical	None identified
	Reducing hospitalizations, admission ICU, deaths	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Negative effects	Moderate (n=2) (1; 59)	• The adverse effect on excess mortality increased with the duration and intensity of 10 PHSMs, which was associated with an increase of 44.16% [RR = 1.44, 95% CI: 1.27-1.64] in the excess mortality under the strict intervention (the intensity above the 80th centile and lasted for 21 days) (1) • PHSMs were associated with 71.5% decrease in PEP (post-exposure prophylaxis) prescriptions (IRR 0.285; 95% CI 0.192-0.23), 36.1% decrease in HIV tests (0.639, 0.497-0.822), 32.0% decrease in HIV diagnoses (0.680, 0.511-0.904), 59.3% increase in time intervals (1.593, 1.270-1.997) and 17.4% decrease in CD4 counts (0.826, 0.746-0.915) in the first week during PHSMs (59) o The majority of outcomes occurred in males (55.3-87.4%), 21-50 year olds (51.7-90.5%), Southwestern China (38.2-82.0%) and heterosexual transmission (47.9-66.1%) (59)
		Serious (n=1) (62)	• Change in both anxiety and depression symptoms was moderated by the strictness of government restrictions; depression symptoms increased more, and anxiety symptoms decreased less for participants in regions with higher levels of government restrictions (62)
		Critical	None identified

Table 2: Principal findings for each PHSM identified

Type of PHSM	Operationalization of PHSM	Risk of bias for studies that examine PHSMs	Overall results of studies with moderate risk of bias
Quarantine and isolation	Quarantine policies	Moderate (n=1) (11) Serious (n=1) (39)	**Reducing transmission of COVID-19** o One multi-country study found an association with reductions of the Rt number (11) o One study in the U.S. (serious RoB) found that quarantine appears to have had inadequate coverage and adoption during the infectious periods, limiting its effectiveness at reducing transmission in the community (39)
			Reducing transmission of other RIDs o No evidence identified
			Reducing hospitalizations, admission ICU, deaths o No evidence identified
			Negative effects o No evidence identified
	Contact tracing strategies	Moderate (n=1) (42) Serious (n=2) (39; 57)	**Reducing transmission of COVID-19** o One study in the U.S. (serious RoB) found that contact tracing appears to have had inadequate coverage and adoption during the infectious periods, limiting its effectiveness at reducing transmission in the community (39)
			Reducing transmission of other RIDs o No evidence identified
			Reducing hospitalizations, admission ICU, deaths o One multi-country study found no significant effect on reducing deaths attributed to COVID-19 (42)
			Negative effects o One multi-country study (serious RoB) found a significant negative effect on mental wellbeing measured with WHO-5 score (57)
	Isolation policies	Serious (n=1) (39)	**Reducing transmission of COVID-19** o One study in the U.S. (serious RoB) found that isolation policies appear to have had inadequate coverage and adoption during the infectious periods, limiting their effectiveness at reducing transmission in the community (39)
			Reducing transmission of other RIDs o No evidence identified
			Reducing hospitalizations, admission ICU, deaths o No evidence identified
			Negative effects o No evidence identified
			Reducing transmission of COVID-19 o No evidence identified

	Workplace policies that support sick days		**Reducing transmission of other RIDs** o No evidence identified
			Reducing hospitalizations, admission ICU, deaths o No evidence identified
			Negative effects o No evidence identified
Masks	Mask mandate or mask requirement	Moderate (n=10) (4; 11; 18; 20; 27-30; 42; 47) Serious (n=7) (16; 17; 39; 41; 44; 51; 65) Critical (n=5) (23; 31; 48; 64; 66)	**Reducing transmission of COVID-19** o Three multi-country studies found mask mandates to be the most effective PHSM in the second wave/pre-vaccination period (18; 27; 28), and four other multi-country studies found effectiveness on reducing transmission (4; 11; 20; 29) o One multi-country study found that in France, mask wearing was more effective to support deconfinement than for suppress transmission (30)
			Reducing transmission of other RIDs o One multi-country study (serious RoB) reported an association with a reduced bronchiolitis caseload (51)
			Reducing hospitalizations, admission ICU, deaths o One multi-country study found neutral initial effects on cumulative mortality, followed by rises in deaths (29), while another multi-country study found no significant effect on reducing deaths attributed to COVID-19 (42) o One study in Switzerland found that the extension of compulsory mask wearing to public places has an heterogeneous impact on mortality, with small positive effects on male mortality entirely driven by older age-cohorts (90+) (47)
			Negative effects o No evidence identified
Ventilation			**Reducing transmission of COVID-19** o No evidence identified
			Reducing transmission of other RIDs o No evidence identified
			Reducing hospitalizations, admission ICU, deaths o No evidence identified
			Negative effects o No evidence identified
Physical distancing and reduction of contacts	Physical distancing policies/mandates	Serious (n=2) (39; 40) Critical (n=2) (39; 67)	**Reducing transmission of COVID-19** o One study in the U.S. (serious RoB) found higher incidence of COVID-19 among those who dined indoors at restaurants or bars (IRR=1.93, 95% CI 1.39-2.70); and those who visited a place of worship (IRR=1.92, 95% CI 1.26-2.84) (39)
			Reducing transmission of other RIDs o One study in South Korea (critical RoB) found that after the relaxing of the physical distancing policy, the number of patients with respiratory virus (other than COVID-19) significantly increased (39)
			Reducing hospitalizations, admission ICU, deaths o One multi-country study found a tentative non-significant trend in changing deaths (42)

			Negative effects ○ No evidence identified
	Lockdowns/stay-at-home orders	Moderate (n=9) (2; 4; 12; 29; 30; 34; 35; 43; 58) Serious (n=13) (5; 17; 22; 38; 41; 44; 45; 51; 52; 60; 61; 65; 68) Critical (n=7) (13; 19; 23; 46; 64; 67; 69)	**Reducing transmission of COVID-19** ○ Five multi-country studies reported a significant effect in reducing transmission (2; 4; 30; 34), one multi-country study suggested that as the number of lockdown days increased, so did the number of cases (29), another multi-country study found that adjusting for other cointerventions, stay-at-home orders are the least effective PHSM (35)
			Reducing transmission of other RIDs ○ One multi-country study (serious RoB) reported an association with a reduced bronchiolitis caseload (51), and another multi-country (serious RoB) reported a reduction of RSV activity (52)
			Reducing hospitalizations, admission ICU, deaths ○ Two multi-country study identified a non-significant tentative change in trend of deaths (42; 43), while another multi-country study found an inverted U-quadratic effect, with an initial rise of deaths followed by a decrease (29)
			Negative effects ○ One multi-country study found an association with anxiety and depressive symptoms, stronger among males (58)
	Gathering restrictions	Moderate (n=12) (2; 4; 12; 18; 28-30; 32; 35; 42; 43; 58) Serious (n=7) (5; 38; 41; 45; 57; 65; 68) Critical (n=4) (9; 13; 23; 67)	**Reducing transmission of COVID-19** ○ Eight multi-country studies found a strong effect in reducing transmission, the more restrictive were most effective, especially in the second wave (2; 4; 12; 18; 28; 29; 32; 35) ○ One multi-country study found that in France, restrictions on gathering was more effective for support deconfinement than for suppress the transmission (30)
			Reducing transmission of other RIDs ○ No evidence identified
			Reducing hospitalizations, admission ICU, deaths ○ Three multi-country studies found a significant association with reduction of deaths (29; 42; 43)
			Negative effects ○ One multi-country study found an association with anxiety and depressive symptoms, stronger among females (58)
	Work from home policies and workplace closures	Moderate (n=9) (2; 18; 20; 28; 34; 35; 42; 43; 58) Serious (n=5) (5; 38; 41; 51; 68) Critical (n=4) (8; 13; 23; 67)	**Reducing transmission of COVID-19** ○ Five multi-country studies found moderate effect on reducing transmission, which was most evident in the second wave (2; 18; 20; 28; 34), one study found it to be the least effective among the PHSMs (35)
			Reducing transmission of other RIDs ○ One multi-country study (serious RoB) reported an association with reduced bronchiolitis caseload (51)
			Reducing hospitalizations, admission ICU, deaths ○ One multi-country study identified a non-significant tentative change in trend of deaths (42), while another multi-country study found after adjusting for multiple concurrent interventions and confounders, and accounting for both timing and strictness of interventions, that earlier and stricter workplace closure was associated with lower COVID-19 mortality rates (43)
			Negative effects

			○ One multi-country study found no association with either anxiety or depressive symptoms in females or males (58)
	School closure	Moderate (n=12) (4; 12; 18; 20; 27-29; 35; 37; 42; 43; 58) Serious (n=9) (17; 22; 38; 41; 45; 51-53; 65) Critical (n=3) (13; 23; 31)	**Reducing transmission of COVID-19** ○ Six multi-country studies found a moderate effect on reducing the transmission;(12; 18; 20; 28; 29; 35) one multi-country study found a negligible effect during the second wave,(4) while another multi-country study found an increase in the average daily growth rate in the post-vaccination period (27) ○ One study in Japan found that adjusting by PHSMs like reduction of gatherings, lockdowns, and business closures, the effect of school closures on the spread of COVID-19 in early 2020 did not reduce the number of cases of COVID-19 (48)
			Reducing transmission of other RIDs ○ Three multi-country studies (serious RoB) reported strong significant protective effect against bronchiolitis (51), Respiratory Syncytial Virus (52), and Influenza (53)
			Reducing hospitalizations, admission ICU, deaths ○ Two multi-country studies reported a negative and significant effect on reducing deaths,(29; 43) one of them found a stronger effect when implemented earlier and stricter;(43) another multi-country study found no significant effect on reducing deaths attributed to COVID-19 (42)
			Negative effects ○ One multi-country study found no association with either anxiety or depressive symptoms in females or males (58)
	Business closures	Moderate (n=6) (4; 12; 29; 32; 33; 42) Serious (n=1) (45) Critical (n=3) (23; 46; 49)	**Reducing transmission of COVID-19** ○ Four multi-country studies reported a moderate effect on reducing transmission,(4; 12; 32) one multi-country study found a non-significant effect of the closure of non-essential businesses (29) ○ One study in the U.S. found that keeping indoor dining closed was associated with moderate reductions in the new COVID-19 case rate over six weeks (59)
			Reducing transmission of other RIDs ○ No evidence identified
			Reducing hospitalizations, admission ICU, deaths ○ One multi-country study found a significant effect on reducing deaths,(29) while another multi-country study reported a significant association with an increase of deaths in some groups of countries (42)
			Negative effects ○ No evidence identified
	Public transport bans	Moderate (n=4) (2; 18; 27; 42) Serious (n=5) (5; 16; 38; 41; 52) Critical (n=2) (13; 49)	**Reducing transmission of COVID-19** ○ Three multi-country studies found a weak to moderate effect on reducing transmission (2; 18; 27)
			Reducing transmission of other RIDs ○ One multi-country study (serious RoB) found associations with reductions of Respiratory Syncytial Virus infections (52)
			Reducing hospitalizations, admission ICU, deaths ○ One multi-country study found no significant effect on reducing deaths attributed to COVID-19 (42)
			Negative effects

			○ No evidence identified
Hand hygiene and respiratory etiquette			**Reducing transmission of COVID-19** ○ No evidence identified
			Reducing transmission of other RIDs ○ No evidence identified
			Reducing hospitalizations, admission ICU, deaths ○ No evidence identified
			Negative effects ○ No evidence identified
Cleaning and disinfecting			**Reducing transmission of COVID-19** ○ No evidence identified
			Reducing transmission of other RIDs ○ No evidence identified
			Reducing hospitalizations, admission ICU, deaths ○ No evidence identified
			Negative effects ○ No evidence identified
Other common PHSMs considered	International travel restrictions	Moderate (n=8) (2; 18; 27; 35; 36; 42; 43; 58) Serious (n=8) (5; 16; 38; 40; 41; 57; 64; 70) Critical (n=3) (13; 31; 49)	**Reducing transmission of COVID-19** ○ Overall, four multi-country studies found a strong effect on reducing transmission, especially in the first wave (2; 18; 27; 36), and one found a weak effect (35) ○ One multi-country study found that longer maintenance of the border quarantine was significantly associated with lower infections in high-prevalent countries, while imposing bans on regions showed no suppressing effects but significantly higher COVID-19 incidence (36)
			Reducing transmission of other RIDs ○ No evidence identified
			Reducing hospitalizations, admission ICU, deaths ○ One multi-country study found no significant effect on reducing deaths attributed to COVID-19,(42) while another multi-country study reported an effect on reducing mortality but only after adjusting for its strictness and considering restrictions on gatherings (43)
			Negative effects ○ One multi-country study found an association with anxiety and depressive symptoms, stronger among males (58)
	Domestic travel restrictions	Moderate (n=3) (15; 42; 58) Serious (n=5) (5; 9; 38; 41; 52) Critical (n=1) (9)	**Reducing transmission of COVID-19** ○ One study in China found that the Wuhan city travel ban meaningfully slowed the dispersal of infection to other cities (15) ○ One multi-country study (serious RoB) found stricter travel restrictions to be effective in reducing spread rate (5), while another multi-country study (serious RoB) found it negligible (38)
			Reducing transmission of other RIDs ○ One multi-country study (serious RoB) found an association with less Respiratory Syncytial Virus infections (52)

			Reducing hospitalizations, admission ICU, deaths o One multi-country study found no significant effect on reducing deaths attributed to COVID-19 (42)
			Negative effects o One multi-country study found strong association with anxiety and depressive symptoms among females (58)
	Testing	Moderate (n=2) (27; 28) Serious (n=1) (39) Critical (n=1) (13)	**Reducing transmission of COVID-19** o Two multi-country studies found testing effective when widespread to the public and not only focused on people with symptoms (27; 28) o One study in the U.S. (serious RoB) found that testing policies appear to have had inadequate coverage and adoption during the infectious periods, limiting their effectiveness at reducing transmission in the community (39)
			Reducing transmission of other RIDs o No evidence identified
			Reducing hospitalizations, admission ICU, deaths o Two studies reported no significant effect on reducing deaths attributed to COVID-19 (32; 42)
			Negative effects o No evidence identified
	Public information campaigns/risk communication	Serious (n=2) (40; 41) Critical (n=1) (13)	**Reducing transmission of COVID-19** o One multi-country study (serious RoB) found risk communication effective in reducing case growth (40), while another multi-country study found negligible effects (41)
			Reducing transmission of other RIDs o No evidence identified
			Reducing hospitalizations, admission ICU, deaths o No evidence identified
			Negative effects o No evidence identified

Table 3. Summary of findings of studies reporting on the effectiveness of combinations of PHSMs over time and across jurisdictions for reducing transmission of COVID-19

Type of PHSM	Operationalization of PHSM	Category of comparison	Number of studies	Synthesis by categories of comparison	General conclusion
Quarantine and isolation	Quarantine policies	Period studied	Only first half 2020 (n=1)(11)	The study found an association with reductions of the Rt number	Quarantine policies were reported to have limited effectiveness in reducing transmission; the effect might depend on their coverage and adherence **2/2 studies support weak effectiveness**
			Most of 2020 and 2021 (n=1) (39)	This study in the U.S. found that quarantine appear to have had inadequate coverage and adoption during the infectious periods, limiting their effectiveness	
		Country focus	Multi-country (n=1) (11) Single country (n=1) (39)	Both studies found limited effectiveness	
		Risk of bias	Moderate (n=1) (11) Serious (n=1) (39)	Both studies found limited effectiveness	
	Contact tracing strategies	Period studied	Most of 2020 and 2021 (n=1) (39)	One study in the U.S. found that contact tracing appears to have had inadequate coverage and adoption during the infectious periods, limiting their effectiveness at reducing transmission in the community	**One study** found contact tracing to have limited effectiveness in reducing transmission
		Country focus	Single country (n=1) (39)		
		Risk of bias	Serious (n=1) (39)		
	Isolation policies	Period studied	Most of 2020 and 2021 (n=1) (39)	One study in the U.S. found that isolation policies have had inadequate coverage and adoption during the infectious periods, limiting their effectiveness at reducing transmission in the community	**One study** found isolation policies to have limited effectiveness in reducing transmission
		Country focus	Single country (n=1) (39)		
		Risk of bias	Serious (n=1) (39)		
	Workplace policies that support sick days	Period studied	No identified	• No studies identified	No studies identified
		Country focus	No identified		

		Risk of bias	No identified		
Masks	Mask mandate or mask requirement	Period studied	Only first half of 2020 (n=5) (11; 17; 29; 65; 66)	• All studies found mask-wearing to reduce Rt number by 15% - 19%	Mask-wearing was one of the most effective PHSMs in reducing transmission; the effect was stronger with stricter use **16/17 studies support moderate to strong effectiveness**
			Most of or all 2020 (n=5) (23; 28; 41; 48; 64)	• All studies found mask-wearing to be among the most effective PHSM, varying between 8.8% - 71%	
			Most of 2020 and 2021 (n=7) (4; 18; 20; 27; 30; 31; 39)	• Six studies found stricter mask-wearing to have the highest effect	
		Country focus	Multi-country (n=13) (4; 11; 18; 20; 23; 27-31; 41; 65; 66)	• Twelve studies found mask-wearing to be an effective intervention	
			Single country (n=4) (17; 39; 48; 64)	• All studies (U.S.=2, Canada=1, Australia=1) found mask-wearing to be effective in reducing transmission (~18%)	
		Risk of bias	Moderate (n=8) Serious (n=5) Critical (n=4)	• Except for one study (critical RoB), all studies reported mask-wearing to be effective in reducing transmission • Most of the studies with moderate RoB found a moderate to strong effect in reducing transmission (12% - 38%)	
Ventilation	Ventilation	Period studied	No identified	• No studies identified	No studies identified
		Country focus	No identified		
		Risk of bias	No identified		
Physical distancing and reduction of	Physical distancing policies/mandates	Period studied	Only first half 2020 (n=2)(40; 67)	• All studies found significant effect of physical distancing	Physical distancing was found highly effective in reducing transmission; the effect was stronger with mandatory than
			Most of 2020 and 2021 (n=1) (39)		
		Country focus	Multi-country (n=2) (40; 67)		

			Single country (n=1) (39)		with voluntary measures **3/3 studies support strong effectiveness**
		Risk of bias	Serious (n=2) Critical (n=1)		
	Lockdowns/stay-at-home orders	Period studied	Only first half 2020 (n=14) (2; 5; 12; 13; 17; 19; 29; 35; 38; 45; 46; 65; 67; 68)	• Twelve studies found lockdown somehow effective two to three weeks after implementation • Studies that controlled by other cointerventions found an effect ranging between 13% - 23% • Two studies reported negligible effect	At the top of other PHSMs, lockdown/ stay-at-home interventions were found effective in reducing the transmission of COVID-19; among the fourteen studies that only covered the first half of the pandemic, two multi-country studies of moderate RoB found a negligible effect of this intervention **20/22 studies support weak to strong effectiveness**
			Most of or all 2020 (n=5) (23; 34; 41; 64; 69)	• All studies found lockdown effective in reducing transmission of COVID-19, studies that controlled by other cointerventions found an effect ranging from 3% - 7%	
			Most of 2020 and 2021 (n=3) (4; 22; 30)	• All studies found a significant effect of stricter lockdown in reducing transmission, ranging from 26% -52%	
		Country focus	Multi-country (n=16) (2; 4; 5; 12; 13; 19; 23; 29; 30; 34; 35; 38; 41; 65; 67; 68)	• Fourteen found lockdown effective in reducing COVID-19 transmission	
			Single country (n=6) (17; 22; 45; 46; 64; 69)	• All studies (U.S.= 3, Australia=1, Ireland=1, Japan=1) found lockdown effective, principally when implemented earlier	
		Risk of bias	Moderate (n=7) Serious (n=8) Critical (n=7)	• Two of the seven studies with moderate RoB found a negligible effect of lockdown after adjusting by cointerventions • All other studies of moderate, serious, and critical RoB found lockdown effective	
	Gathering restrictions	Period studied	Only first half 2020 (n=11) (2; 5; 12; 13; 29; 35; 38; 45; 65; 67; 68)	• Ten studies found gathering restrictions to be effective (four to six weeks after implementation)	Gathering restrictions were found effective in reducing the

				• The effect was higher when the interventions were stricter, limiting gatherings to less than 1,000 people (23% - 37%), to less than 100 people (18% - 34%), and less than ten people (9% - 42%)	transmission of COVID-19; the effect was more substantial when the intervention was stricter; only one single-country study of critical RoB found no effect of this intervention after controlling by the time spent at home **18/19 studies support moderate to strong effectiveness**
			Most of or all 2020 (n=4) (23; 28; 32; 41)	• All studies found gathering restrictions to less than 50 people to be an effective intervention in reducing transmission by 3% - 15%	
			Most of 2020 and 2021 (n=4) (4; 9; 18; 30)	• All studies found gathering restrictions to less than ten people, to be an effective intervention in reducing transmission (26% - 32%)	
		Country focus	Multi-country (n=17) (2; 4; 5; 12; 13; 18; 23; 28-30; 32; 35; 38; 41; 65; 67; 68)	• All studies found gathering restrictions effective in reducing transmission	
			Single country (n=2) (9; 45)	• After controlling by the time spent at home, the U.S. study found no effect on reducing transmission; while the study in Spain found a significant effect on reducing the Rt	
		Risk of bias	Moderate (n=9) Serious (n=6) Critical (n=4)	• All nine studies with moderate RoB found a significant effect on reducing transmission; in three studies, the stricter intervention was one of the most effective PHSMs • All studies of serious RoB and three of the studies of critical RoB found the intervention effective	
	Work-from-home policies and workplace closures	Period studied	Only first half of 2020 (n=7) (2; 5; 13; 35; 38; 67; 68)	• All studies reported some effectiveness, three studies reported a modest effect (1%-15%), and one study reported a significant impact (53%)	Work-from-home/workplace closure was found of moderate effectiveness 25-30 days after implementation; the effect was lower in
			Most of or all 2020 (n=4) (23; 28; 34; 41)	• All studies found workplace closure/work-from-home to have a weak effect in reducing transmission	

				(4.5% - 10%); the effect appears 25-30 days after implementation	the second and third waves **14/14 studies support weak to moderate effectiveness**
			Most of 2020 and 2021 (n=3) (8; 18; 20)	• All studies found this PHSM effective, one study reported a reduction in transmission of 28% in the first two waves that declined to 9.7% in the third wave	
		Country focus	Multi-country (n=13) (2; 5; 13; 23; 28; 34; 35; 38; 41; 67; 68) Single country (n=1) (8; 18; 20)	• All multi-country and Taiwan studies reported some effect in reducing transmission	
		Risk of bias	Moderate (n=6) Serious (n=4) Critical (n=4)	• All studies reported some level of effectiveness • Four studies of moderate RoB found a modest effect on reducing transmission, which declined in the second and third waves	
	School closure	Period studied	Only first half of 2020 (n=8) (12; 13; 17; 29; 35; 37; 38; 65)	• Seven studies found a significant effect of school closure in reducing COVID-19 transmission (17% - 38%), one study found no effect	Most of the studies found school closure to be effective in reducing transmission; however, the level of effectiveness reported was inconsistent (varying from negligible to strong), only one study disaggregated the effect of closing universities and schools at secondary, primary or preschool levels
			Most of or all 2020 (n=5) (23; 28; 31; 41; 45)	• All studies found that school closure reduces transmission	
			Most of 2020 and 2021 (n=5) (4; 18; 20; 22; 27)	• Two studies reported a strong effect, one study reported a negligible effect, and one study found that in the post-vaccination period, school closure increased the COVID-19 transmission	
		Country focus	Multi-country (n=14) (4; 12; 13; 18; 20; 23; 27-29; 31; 35; 38; 41; 65)	• Thirteen studies reported different levels of effectiveness	

			Single country (n=4) (17; 22; 37; 45)	• Two studies conducted in the U.S. reported effectiveness, and two conducted in Japan reported contradictory findings • One of the studies conducted in Japan, with moderate RoB and only analyzing the first half of the pandemic, reported no effectiveness, while the other study of serious RoB analyzing years 2020 and 2021 found that only school closures during periods of voluntary PHSMs implementation showed significant differences in reducing the Rt	**15/18 studies support weak to strong effectiveness, two studies support no effect, and one study found an increase in cases in post-vaccination period**
		Risk of bias	Moderate (n=9) Serious (n=6) Critical (n=3)	• From the nine studies with moderate RoB, four reported a strong effect in reducing transmission (12-38%), two reported some effect, two found a negligible or no effect, and one study found that in the post-vaccination period, school closure increased the COVID-19 transmission • The six studies with serious RoB and the three with critical RoB reported some level of effectiveness (2%-38%), one of the studies found the closure of universities to be more effective than the closure of schools at secondary, primary, or preschool levels	
	Business closures	Period studied	Only first half of 2020 (n=4) (12; 29; 45; 46)	• Three studies found an effect on reducing COVID-19 transmission, one study found no effect	Most of the studies found the closure of non-essential business to be effective in reducing transmission/number of cases; the effect varied according strictness and type of
			Most of or all 2020 (n=3) (23; 32; 33)	• All studies found that closure of non-essential business reduces transmission	
			Most of 2020 and 2021 (n=2)(4; 9)	• The two studies found a significant effect in reducing transmission, especially in the second wave (35%)	

		Country focus	Multi-country (n=5) (4; 12; 23; 29; 32)	• Four studies found this PHSM effective in reducing transmission	business considered in the analysis **8/9 studies support moderate to strong effectiveness**
			Single country (n=4) (9; 33; 45; 46)	• All single country studies (U.S.= 3, Spain=1) found the closure of non-essential business to be effective, one study in the U.S. found null effect when this PHSM was evaluated alongside average time spent at home	
		Risk of bias	Moderate (n=5) Serious (n=4) Critical (n=3)	• Four of the studies with moderate RoB reported a significant effect in reducing transmission/ number of cases (18%-55%), the effect varied according strictness and type of business considered • All the four studies with serious and critical RoB found this PHSM to be somehow effective	
	Public transport bans	Period studied	Only first half of 2020 (n=4) (2; 5; 13; 38)	• Two studies found a moderate effect in reducing transmission (15%), and two found a negligible effect	Most studies found public transport bans to have a negligible effect in reducing transmission/number of cases; two studies covering exclusively the first half of the pandemic found a moderate effect **5/7 studies support weak effectiveness**
			Most of or all 2020 (n=1)(41)	• The study found a negligible effect of 1%	
			Most of 2020 and 2021 (n=2) (18; 27)	• The two studies found a negligible effect in reducing transmission, especially in the second wave (less than 1%) and pos-vaccination period (4.4%)	
		Country focus	Multi-country (n=7) (2; 5; 13; 18; 27; 38; 41)	• Five studies found a negligible effect	
		Risk of bias	Moderate (n=3) Serious (n=3) Critical (n=1)	• Most studies found a negligible effect, only one study of moderate RoB and one of serious RoB found moderate effectiveness	
Hand hygiene and	Hand hygiene and respiratory etiquette	Period studied	No identified	• No studies identified	No studies identified
		Country focus	No identified		

		Risk of bias	No identified		
Cleaning and disinfecting	Cleaning and disinfecting	Period studied	No identified	• No studies identified	No studies identified
		Country focus	No identified		
		Risk of bias	No identified		
Other common PHSMs considered	International travel restrictions	Period studied	Only first half of 2020 (n=7) (2; 5; 13; 35; 38; 40; 70)	• All studies found a weak to moderate effect in reducing transmission (10% or less), the effect appears 10-14 days after implementation	Most studies found some level of effectiveness of international travel restrictions, all studies of moderate RoB found this intervention to be effective principally in the pre-vaccination period **7/13 studies support moderate to strong effectiveness, 2/13 support weak effectiveness, and 2/13 support no effect**
			Most of or all 2020 (n=3) (31; 41; 64)	• All studies found negligible or no effect	
			Most of 2020 and 2021 (n=3) (18; 27; 36)	• All studies found international travel restrictions to be one of the most effective PHSMs, one study found that was the most effective during the first wave (41.4%) and was one of the four PHSMs with the highest impacts before vaccine implementation (36%)	
		Country focus	Multi-country (n=12) (2; 5; 13; 18; 27; 31; 35; 36; 38; 40; 41; 70)	• All studies found this PHSM effective	
			Single country (n=1) (64)	• The border closure in South Australia reduced the incidence of cases in approximately 18%	
		Risk of bias	Moderate (n=5) Serious (n=5) Critical (n=3)	• The five studies with moderate RoB found a stronger effect of international travel restrictions on reducing COVID-19 transmission/number of cases • The five studies with serious RoB find weak to moderate effect • Two studies with critical RoB found this PHSM to be ineffective	

	Domestic travel restrictions	Period studied	Only first half of 2020 (n=3) (5; 15; 38)	• Two studies found a weak effect in reducing transmission (9.5% or less); the other study reported a negligible effect	Studies found domestic travel restrictions to have weak to no effect in reducing transmission **3/5 studies support weak effect, 2/5 support negligible or no effect**
			Most of or all 2020 (n=1) (41)	• The study found that domestic movement restrictions operated over a horizon of around 25 days with an effect of 1.9%	
			Most of 2020 and 2021 (n=1)(9)	• This study found no significant lowering effect on the Rt	
		Country focus	Multi-country (n=3) (5; 38; 41)	• Two studies found a weak effect and one study reported a negligible effect	
			Single country (n=2) (9; 15)	• One study in China found that the Wuhan city travel ban slowed the dispersal of infection to other cities by an estimated 2.91 days on average; the study in Spain found no significant lowering effect on the Rt	
		Risk of bias	Moderate (n=1) Serious (n=3) Critical (n=1)	• The study of moderate RoB reported some effect in slowing the transmission, two of the studies of serious RoB reported weak effect, and one serious and one critical RoB studies found negligible or no effect	
	Testing	Period studied	Only first half of 2020 (n=1)(13)	• The study found only a weak effect on reducing Rt	Studies found testing to have a weak effect on reducing transmission, the effectiveness is increased when testing is widespread to asymptomatic people **4/4 studies support weak to negligible effectiveness**
			Most of or all 2020 (n=1) (28)	• In the period October-December 2020, changes from testing those with symptoms and meeting specific criteria to testing asymptomatic people were associated with an average increase in the number of cases of 0.83%	
			Most of 2020 and 2021 (n=2) (27; 39)	• One study in the U.S. found that testing appears to have had inadequate coverage and adoption during the infectious periods, limiting their effectiveness at reducing transmission, another study found that the widespread o testing to asymptomatic	

				people reduced the number of cases by 1.73% compared with a policy that only focused on people with symptoms	
		Country focus	Multi-country (n=3) (13; 27; 28)	• All studies found testing effective, principally when it was widespread to asymptomatic people	
			Single country (n=1)(39)	• The U.S. study found that the limited coverage and adoption of testing affected its effectiveness	
		Risk of bias	Moderate (n=2) Serious (n=1) Critical (n=1)	• Both studies of moderate RoB found that testing asymptomatic people is more effective than testing only symptomatic or people that meet specific criteria; the effect ranged between 0.64%-1.73% • The studies of serious and critical RoB reported a weak or negligible effect	
	Public information campaigns/risk communication	Period studied	Only first half of 2020 (n=1) (13)	• Public information campaigns had moderate effect under an scenario of maximum effort in implementing PHSMs	Studies found public information campaigns/risk communication to have a moderate effect on reducing transmission/ number of cases **2/3 studies support moderate effectiveness, one study support negligible effect**
			Most of or all 2020 (n=2) (40; 41)	• One study found that the estimated aggregated effectiveness of risk communication was of 22.4% in reducing the number of cases, the other study found a negligible effect	
		Country focus	Multi-country (n=3) (13; 40; 41)	• Two studies reported moderate effect and one study found a negligible effect	
		Risk of bias	Serious (n=2) Critical (n=1)	• One study of serious RoB and one of critical RoB reported a moderate effect, the other study of serious RoB found a negligible effect	

Table 4: Principal findings of studies reporting on effectiveness of combined PHSMs for reducing transmission of COVID-19 organized by PHSM and risk of bias

Type of PHSM	Operationalization of PHSM	RoB	Principal findings
Quarantine and isolation	**Quarantine policies**	Moderate (n=1) (11)	• The implementation of quarantine was associated with changes of -11.4% [from -13.66% to -9.07%] in the Rt number (11)
		Serious (n=1) (39)	• In the U.S., one study found that PHSMs such as quarantining appear to have had inadequate coverage and adoption during the infectious periods, limiting their effectiveness at reducing SARS-CoV-2 transmission in the community (39)
		Critical	None identified
	Contact tracing strategies	Moderate	None identified
		Serious (n=1) (39)	• In the U.S., one study found that PHSMs such as contact tracing appear to have had inadequate coverage and adoption during the infectious periods, limiting their effectiveness at reducing SARS-CoV-2 transmission in the community (39)
		Critical	None identified
	Isolation policies	Moderate	None identified
		Serious (n=1) (39)	• In the U.S., one study found that PHSMs such as isolation appear to have had inadequate coverage and adoption during the infectious periods, limiting their effectiveness at reducing SARS-CoV-2 transmission in the community (39)
		Critical	None identified
	Workplace policies that support sick days	Moderate	None identified
		Serious	None identified
		Critical	None identified
Masks	**Mask mandate or mask requirement**	Moderate (n=8) (4; 11; 18; 20; 27-30)	• In the second wave, facial coverings became the PHSM with the highest effect on reducing transmission growth rate, the median effect was 38.0% [IQR 33.2-39.5%], and was one of the four PHSMs with the highest impacts (>30%) before vaccine implementation, the median effect was 33.6% [IQR 27.0-40.4%] (18) • In the second wave, mask-wearing requirements ranked fourth in terms of effect (28) • In the pre-vaccination period, based on the average marginal effect (AME) estimated, wearing masks was the most effective PHSM to reduce the average daily growth rate (wADGR) (27) o Making stricter the facial covering policy from "no recommended or required wear mask outside the home" to "recommended or required wear mask at some public space" to "required wear mask in all public spaces" to "required wear mask all the time", was associated with reductions in the average daily growth rate (wADGR) of 2.03%, 1.25%, and 0.78%, respectively (27) • Introduction of policies that require mask-wearing in most or all shared/public spaces reduced transmission by 12% [95% CI: 7-17%] (4) • Mask-wearing mandates/advisories seem to have initial negative effects, followed by rises in cases (29)

			• The implementation of mandatory masks was associated with changes of -15.14% [from -21.79% to -7.93%] in the Rt number (11) • Face mask usage caused a persistent reduction on Rt after their initiation, by the end of three weeks, masks had continuously reduced Rt until 0.81 [95% CI: 0.73, 0.88] (20) • In France, mask wearing was identified as a PHSM more effective for support deconfinement than for suppress the transmission (30)
		Serious (n=4) (17; 39; 41; 65)	• Masks had the highest impact on reducing the daily growth rate (8.8%) and played an important role in reducing the number of COVID-19 cases within a period of approximately one month, while also being the most cost-effective method, one study suggested that masks should be introduced immediately when a new pandemic emerges as this is both an effective and relatively cheap policy with no adverse effects on mobility or economic growth (41) • One study found that earlier implementation of PHSMs had a larger impact on the reduction of Rt, with masks reducing infection in 17% (95% CI: 6-28%) (65) • In the U.S., one study found that face-mask orders were associated with an 18% reduction (95% CI 16-20%) (17) • In the U.S., one study found a higher incidence of COVID-19 among people who wore a mask only sometimes while grocery shopping (IRR=10.57, 95% CI 4.00-30.51); those who visited indoors with people not in their own household while sometimes wearing a mask (IRR=1.94; 95% CI 1.37-3.31) or while never wearing a mask (IRR=2.62; 95% CI 1.50-4.70); those working indoors at a place of employment while never wearing a mask (IRR=2.50, 95% CI 0.98-5.26); those who wore masks only sometimes while attending a salon or gym (IRR=3.23, 95% CI 1.90-5.23) (39)
		Critical (n=5) (23; 31; 48; 64; 66)	• Adjusted by other PHSMs and mobility in each region, the mean observed effect level of mask-wearing corresponds to a 19% decrease in the reproduction number Rt (66) • Mandated mask-wearing did not show strong temporal overlap with epidemic growth across 11 countries evaluated (31) • The combination of PHSMs implemented across Europe had a high efficiency at reducing transmission rates, with a median reduction of 71%, recommendations for the use of protective masks, whether on a voluntary or mandatory basis, were the only PHSM that did not result in significant improvements in efficiency (23) • In Canada, one study used both within-province variation from Ontario and cross-province variation in the timing of mandates, finding robust and consistent significantly negative association between mask mandates and subsequent COVID-19 case growth (20 to 22% average weekly reduction in new cases) (48) • In Australia, mask-wearing in Victoria had a pronounced lag effect of two weeks with an incidence rate ratio (IRR) of 0.27 (95%CI 0.26-0.29) (64)
Ventilation		Moderate	None identified
		Serious	None identified
		Critical	None identified
		Moderate	None identified

Physical distancing and reduction of contacts	**Physical distancing policies/mandates**	Serious (n=2) (39; 40)	• Social distancing policy was the second high-scored intervention for reducing Rt (fraction of effective portfolios 0.06) (40) • In the U.S., one study found a higher incidence of COVID-19 among those who dined indoors at restaurants or bars (IRR=1.93, 95% CI 1.39-2.70); and those who visited a place of worship (IRR=1.92, 95% CI 1.26-2.84) (39)
		Critical (n=1) (67)	• Mandatory policies of physical distancing were more effective than non-mandatory policies in reducing mobility, a 10% decrease in mobility was associated with an 11.8% decrease in new cases [95% CI: 3.8%- 19.1%] two weeks later; a more pronounced 50% decrease in mobility resulted in a 46.6% decrease in cases two weeks later [95% CI: 17.5%- 65.4%] (67)
	Lockdowns/stay-at-home orders	Moderate (n=7) (2; 4; 12; 29; 30; 34; 35)	• Defining a lockdown policy as a ban on all gatherings and closure of all non-essential businesses, estimated a total reduction in Rt of 52% [95% CI: 47-56%] (4) • Stay-at-home requirement in the prior 1-28 days was associated with a statistically significant 3.2% [95% CI, 0.4%-7.2%] to 7.1% [95% CI, 3.8%-10.3%] reduction in Country-level transmission risk score (CTRS) (34) • Stay-at-home measures showed a positive association with cases, suggesting that as the number of lockdown days increased, so did the number of cases (29) • On top of all other PHSMs, issuing stay-at-home orders had an additional effect in reducing the Rt by 13% [95% CI, -5 to 31%] (12) • Lockdown type measures, if implemented early, significantly lowered Rt (2) ○ Partial lockdown in comparison to no measures taken reduced Rt by 0.38 [95% CI: -0.72, -0.04]; and a complete lockdown reduces Rt by 0.32 [95% CI: -0.55, -0.09] (2) • Stay-at-home orders appeared to be the least effective among the PHSMs considered in one study (4%; 95% CrI 6% to 17%) (35) • Stay-at-home and partial lockdowns were PHSMs with significant effect in controlling the first wave in Italy and the second wave in Germany (30)
		Serious (n=8) (5; 17; 22; 38; 41; 45; 65; 68)	• For every one level increase of strictness of stay-at-home requirements (e.g., "no restrictions" to "require not leaving the house with minimal exceptions"), the spread rate decreased approximately by 11.02% daily (5) • The stay-at-home requirement was the second most effective PHSM indicator [X = 38.28%, 95% CI 22.53% - 54.03%] for reducing the daily increase rate of total cases (DIRTC) (68) • Stay-at-home requirements, which were generally introduced as a last resort, take more time to bring incidence below the reference period, and when they do, their effect becomes negative and significantly different from zero over a limited number of days (38) • Stay home requirements operated over a horizon of around 25 days and had decreasing impacts of 3.1% over the daily growth rate (41) • In the U.S., one study found that the average Rt for all included territories the week prior to implementing stay-at-home orders (Rt=1.256) compared to the week following (Rt=1.088) was reduced - 13.3% (absolute change =-0.1673, SD=0.070), states with stay-at-home orders preceding

			the date of their 500th case were negatively associated with average Rt (β=-0.15,95% CI -0.23 to -0.07, p<0.001) (45) o In the U.S., one study with dichotomized Rt into values above and below 1, found that implementing a stay-at-home order was associated with a 93% decrease in the odds of having a positive Rt in the week immediately following the 500th case (OR 0.07, 95% CI 0.01 to 0.37, p= 0.0032), in Kaplan Meier analyses, was associated with a decreased probability of reaching 1000 cases within 5 days (log-rank sum, p= 0.02), in cox proportional hazards regression, correlated with an increase in time to reach 1000 cases (OR 0.32, CI 0.16 to 0.66, p= 0.0022) (45) • Earlier implementation of PHSMs had a larger impact on the reduction of Rt, with lockdowns reducing infection in 23% (95% CI: 18-27%) (65) • Japan, one study found that the implementation of full lockdown and PHSMs compulsory with legal repercussions led to an average Rt value <1 in 8 of the 10 prefectures where implemented, with an average relative reduction in the Rt ranging from 26 to 39% (22) • In the U.S., one study found that stay-at-home orders were associated with a 15% reduction in effective basic reproductive number (Reff) (95% CI 13-17%) (17)
		Critical (n=7) (13; 19; 23; 46; 64; 67; 69)	• The largest declines in mobility were associated with mandatory stay-at-home orders, with an effect of -16.7% [95% CI: -23.7% to -9.7%], and mobility was associated with decrease in cases (67) • Stay-at-home requirements had moderate evidence under the any-effort scenario (13) • After subtracting the epidemic and less restrictive PHSMs effects, no apparent, significant beneficial effect was found with more restrictive PHSMs on case growth in any country (19) • In the U.S., early adopters counties of lockdowns and non-essential business closures had a mean of 1.35 (SD 10.53) COVID-19 infections per 100,000 people, whereas late adopters had a mean of 4.09 (SD 12.38) (46) • In Ireland, moderately strict PHSMs were more effective than the strictest Phase 5 (lockdown), both primary and secondary incidence rates exhibited a marked decrease within 5 days of the move from PHSM Phase 2 to Phase 3 being implemented nationwide, followed by a marked and consistent case decrease identified within 5 or 14 days of either nationwide Phase 5 lockdowns (69) • The combination of 13 PHSMs implemented across Europe had a high efficiency at reducing transmission rates, with a median reduction of 71% (interquartile range of 58-81%), adding stay-at-home recommendations for risk groups resulted in the largest increase in efficiency (β=0.24, 95%CI 0.16-0.32) followed by teleworking (β=0.23, 95%CI 0.15-0.31) (23) • In Australia, the effect of border closure (IRR 0.18; 95%CI 0.14-0.22) in South Australia and lockdown (IRR 0.88; 95%CI 0.86-0.91) in Victoria showed a decrease in incidence two weeks after the introduction of these interventions (64)
	Gathering restrictions	Moderate (n=9) (2; 4; 12; 18; 28-30; 32; 35)	• Gathering restrictions became the most effective PHSM on reducing transmission growth rate in the third wave, the median effect was 20.4% [IQR 10.9-34.5%], and was one of the four PHSMs with the highest impacts (>30%) before vaccine implementation, the median effect was 31.7% [IQR 27.2-45.4%] (18)

			• Restrictions on gatherings were negatively related to cumulative morbidity in eight out of nine groups of countries (ranging from -28.64 to -0.20), but all coefficients were not statistically significant (32) • In the second wave, banning all gatherings, including 1-on-1 meetings, had a large effect on reduction in Rt [26%; 95% CI: 18-32%], the small effect associated with more lenient person limits (10 or higher) contrasts with estimates from the first wave, which commonly found bans on much larger gatherings to be effective (4) • Mass gathering restrictions had a negative effect on the number of cases, with fewer cases occurring as the number of days since intervention started increased (29) • For the first period (first case to July 1st 2020), the average marginal effect (AME) estimated indicates that restrictions on gatherings had the highest effect of all PHSMs in reducing COVID-19 average daily growth rate (wADGR) (28) o Changes from "no restrictions on gatherings" to, respectively, "gatherings of more than 100 people not permitted", "gatherings of between 11 and 100 people not permitted", and "gatherings of 10 people or less not permitted", were associated with a respective average reduction in the average daily growth rate (wADGR) of 2.58%, 2.78%, and 2.81% (28) • Limiting gatherings to 1,000 people or less reduced the Rt by 23% [95% prediction interval 0 to 40%]; limiting gatherings to 100 people or less: 34% [12 to 52%]; limiting gatherings to 10 people or less: 42% [17 to 60%] (12) • Rt less than one was observed in countries that either cancelled public events or limited the size of gatherings (2) • Bans of large gatherings were associated with the highest reduction in the number of new infections (37%; 95% CrI 21% to 50%), but the effect was lower for venue closures (18%; 95% CrI 4% to 40%) and bans of small gatherings (9%; 95% CrI 4% to 23%) (35) • In France, restrictions on gathering was identified as a PHSM more effective for support deconfinement than for suppress the transmission (30)
		Serious (n=6) (5; 38; 41; 45; 65; 68)	• For every one level increase of strictness in restrictions of gatherings (i.e., restrictions on gatherings less than 1,000 to less than 100 to between 10 and 100 to less than 10), the spread rate decreased approximately by 5% daily (5) • Restrictions on gatherings was the third most effective PHSM indicator [X = 35.68%, 95% CI 19.80% - 51.56%] for reducing the daily increase rate of total cases (DIRTC) (68) • Compared to the reference pre-intervention period, a unit increase in the value of the intensity of restrictions on private gatherings led to a decrease of about 12% in the number of daily infections 6 weeks after the intervention was implemented (38) • Gathering restrictions were the most useful for achieving a short-term impact of 5.9% on the daily growth rate (41) • In the U.S., PHSMs including school closures, limitations on mass gatherings, non-essential business closure were not found to be associated with Rt when evaluated alongside average time spent at home, neither affected the time from 500 to 1000 cases (45)

			• One study found that earlier implementation of PHSMs had a larger impact on the reduction of Rt, with limits on gatherings reducing infection in 10% (95% CI: 1-18%) (65)
		Critical (n=4) (9; 13; 23; 67)	• Large-gathering bans were associated with the smallest change in mobility compared with other policy types, and mobility was related to reductions in transmission (67) • There was strong evidence for public events cancellation and restriction on gathering under the maximum effort scenario, meaning that a reduction in Rt was only evident when the PHSMs reached their maximum intensity (13) • Bans to gatherings of over 50 people resulted in significant increases in efficiency at reducing transmission rates (over 15%), but less constraining versions, such as limiting mass gatherings to less than 1000 people, led to smaller increases in efficiency (23) • In Spain, there were consistent results with restrictions of gatherings having a statistically significant lowering effect on the Rt (with average coefficients of -0.16) (9)
	Work from home policies or workplace closures	Moderate (n=6) (2; 18; 20; 28; 34; 35)	• A workplace closure policy 1-27 days prior was associated with a 6.8% [95% CI, 0.8%-10.5%] to 10.2% [95% CI, 5.7%-14.5%] reduction in Country-level transmission risk score (CTRS) (34) • For the first period (until July 2020) workplace closing requirements had the second highest effect on reducing the average daily growth rate (wADGR); for the second period (October-December 2020), changes in workplace closing requirements from "no measures" to "require work from home for some sectors" to "require work from home for all-but-essential workplace" were associated with an average decrease in the average daily growth rate (wADGR) of 0.03% and 0.66% (28) • Workplace closure was a PHSM of moderate effect on reducing cases during the second wave, with a reduction of 28.3% [IQR 27.7% -31.8%], its effect declined to 9.7% [IQR 4.2-25.4%] in the third wave (18) • Relative to no measures being taken, policies that recommend working from home reduced Rt by 0.45 [95% CI: -0.82, -0.07] (2) • A combination of a workplace closure policy and stay-at-home requirements 30 days prior exhibited a greater and statistically significant reduction of 6.2% [95% CI, 1.0%-11.2%] to 14.6% [95% CI, 9.9%-19.2%] in the next generation of cases (34) • Work-from-home orders appeared to be the least effective among the PHSMs considered in one study (1%; 95% CrI 8% to 12%) (35) • Wok-from-home mandates caused a persistent reduction on Rt after their initiation, by the end of three weeks, work-form-home had continuously reduced Rt until 0.84 [95% CI: 0.75, 0.93](20)
		Serious (n=4) (5; 38; 41; 68)	• Workplace closure had a coefficient of -0.0785 (t = -3.45), indicating that for every one level escalation of strictness (i.e., from "no measures" to "recommend work from home" to "require work from home for some sectors" to "require work from home for all-but-essential workplace"), the spread rate decreased approximately by 7.85% daily (5) • Workplace closure was the most effective PHSM indicator (X= 53.71%, 95% CI 31.38% - 76.04%) for mitigating the daily increase rate of total cases (DIRTC) (68)

			• Compared to the reference pre-intervention period, a unit increase in the value of the intensity of workplace closures, led to a decrease of 15% in the number of daily infections six weeks after the intervention was implemented (38) • Workplace closures operated over a horizon of around 25 days and had decreasing impacts of 4.5% over the daily growth rate (41)
		Critical (n=4) (8; 13; 23; 67)	• The largest declines in mobility were associated with mandatory workplace closures, effect of -13.3% [95% CI: -20.5% to -6.1%], and mobility was related to reductions in cases (67) • Three PHSMs (workplace closure, income support, and debt/contract relief) had strong evidence for an association under the any-effort scenario only, meaning that the reductions in Rt were associated with the initiation of these interventions, with no evidence of greater effect as they were intensified (13) • In Taiwan, when a level 3 of stringent PHSMs were implemented, prohibiting dine-in services and setting up a work-from-home order reduced the Rt from 0.86 to 0.65 [95% CI 0.57-0.74] (8) • The combination of 13 PHSMs implemented across Europe had a high efficiency at reducing transmission rates, with a median reduction of 71% (interquartile range of 58-81%), adding stay-at-home recommendations for risk groups resulted in the largest increase in efficiency (β=0.24, 95%CI 0.16-0.32) followed by teleworking (β=0.23, 95%CI 0.15-0.31) (23)
	School closure	Moderate (n=9) (4; 12; 18; 20; 27-29; 35; 37)	• School closures was one of the four PHSMs with the highest impacts (>30%) on reducing transmission growth rate before vaccine implementation, the median effect was 36.8% [IQR 27.0-48.3%%] (18) • In the post-vaccination period, school closing at all levels (i.e., primary, secondary and universities) increased the average daily growth rate (wADGR) by 0.33% compared to no measure (27) • School closing had a negligible effect in the second wave, with an effect of 7% on reducing transmission [95% CI: 4-10%] (4) • School closure had a negative effect on the number of cases, with fewer cases occurring as the number of days since intervention started increased (29) • School closing was the third measure most effective in reducing the average daily growth rate (wADGR) (28) • Closing both schools and universities in conjunction reduced the Rt by 38% [95% CI: 16 to 54%] (12) • School closures was associated with a moderate reduction in the number of new infections (17%; 95% CrI 2% to 36%) (35) • Closing schools caused a persistent reduction on Rt after their initiation, by the end of 3 weeks, school closures had continuously reduced Rt until 0.81 [95% CI: 0.63, 0.98] (20) • In Japan, one study found that adjusting by PHSMs like reduction of gatherings, lockdowns, and business closures, the effect of school closures on the spread of COVID-19 in early 2020 was not significantly different from zero, and therefore this PHSM did not reduce the number of cases of COVID-19 (37)

		Serious (n=6) (17; 22; 38; 41; 45; 65)	• Compared to the reference pre-intervention period, a unit increase in the value of the intensity of school closures, led to a decrease of 12% in the number of daily infections 6 weeks after the intervention was implemented (38) • School closures operated over a horizon of around 25 days and had decreasing impacts 2.1% over daily growth rate, one study suggested to focus on the most impactful policies before resorting to this restriction which can have serious long-term effects on the education of children (41) • In the U.S., school closure was associated with a significant reduction in Rt compared to states without these policies the week following 500 cases (β=-0.17, 95% CI -0.30 to -0.05, p= 0.0081); analysis was repeated with an additional week delay (from days 8 to 14 after 500 cases), which yielded similar results (45) o In the U.S., PHSMs including school closures, limitations on mass gatherings, non-essential business closure were not found to be associated with Rt when evaluated alongside average time spent at home, neither affected the time from 500 to 1000 cases (45) • One study found that earlier implementation of PHSMs had a larger impact on the reduction of Rt, with school closures reducing infection in 12% (95% CI: 5-19%) (65) • In Japan, when considered individual interventions, only school closures during periods of voluntary PHSMs implementation showed significant differences in reducing the Rt; no other interventions helped to explain variations in the relative reduction in Rt (22) • In the U.S., one study found that the transmission had the strongest association with school closure (37% reduction in effective basic reproductive number -Reff-, 95% CI 33-40%), followed by daycare closure (31%, 95% CI 26-35%) and banning nursing home visits (26%, 95% CI 23-29%) (17)
		Critical (n=3) (13; 23; 31)	• Implementing a specific package of 4 PHSMs (quarantine and isolation, school closures, household confinement, and the limiting of social gatherings) early and stringently was observed to coincide with lower case counts and transmission durations in Vietnam, Zimbabwe, New Zealand, South Korea, Ethiopia, and Kazakhstan (31) • School closure and internal movement restrictions has strong evidence of reducing the Rt, under both any effort and maximum effort scenarios (13) • Closure of universities and higher education establishments had a larger effect (β=0.23, 95%CI 0.06-0.22) than the closure of schools at secondary, primary or preschool levels (23)
	Business closures	Moderate (n=5) (4; 12; 29; 32; 33)	• In the second wave, business closures were particularly effective, with a combined effect of reducing Rt by 35% [95% CI: 29-41%] (4) o Closures of gastronomy (restaurants, pubs, and cafes) had a large effect on transmission with an estimated reduction in Rt of 12% [95% CI: 8-17%], similar effect was found with closing night clubs [12%, 95% CI: 8-17%] (4) o The combined effect of closing retail and close contact services (such as hairdressers and beauty salons) was considerable [12%, 95% CI: 7-18%]; closing leisure and entertainment venues such as zoos, museums, and theatres had a small effect [3% to 10%] (4) • Closing some high-risk face-to-face businesses reduced the Rt by 18% (-8 to -40%); closing most non-essential face-to-face businesses reduced the Rt by 27% (-3 to -49%) (12)

			• The closure of non-essential businesses did not appear to have a significant effect on the number of COVID-19 cases (29) • Closure of non-essential business was positively related to reductions on cumulative morbidity in all nine groups of countries (ranging from 4.32 to 17.33), and only in three groups was not statistically significant (32) • In the U.S., one study found that keeping indoor dining closed was associated with a 55% (IRR = 0.45; 95% confidence intervals = 0.21, 0.99) decline in the new COVID-19 case rate over 6 weeks compared with cities that reopened indoor dining and maintain other PHSMs (33) ○ Keeping indoor dining closed averted 130 (95% CI = 263, 2.0) daily cases in the average city (33)
		Serious (n=1) (45)	• In the U.S., non-essential business closure was associated with a significant reduction in Rt compared to states without these policies the week following 500 cases (β=-0.13,95% CI -0.21 to -0.05, p= 0.0026); analysis was repeated with an additional week delay (from days 8 to 14 after 500 cases), which yielded similar results (45) ○ In the U.S., PHSMs including school closures, limitations on mass gatherings, non-essential business closure were not found to be associated with Rt when evaluated alongside average time spent at home, neither affected the time from 500 to 1000 cases (45)
		Critical (n=3) (23; 46)	• In the U.S., early adopters counties of lockdowns and non-essential business closures had a mean of 1.35 (SD 10.53) COVID-19 infections per 100,000 people, whereas late adopters had a mean of 4.09 (SD 12.38) (46) • Closure of non/essential business resulted in significant increases in efficiency at reducing transmission rates (over 15%) (23) • In Spain, there were consistent results with mandatory closing times for non-essential businesses having a statistically significant lowering effect on the Rt (with average coefficients of -0.14) (9)
	Public transport bans	Moderate (n=3) (2; 18; 27)	• Travel bans on all regions and lockdown type measures, if implemented early, significantly lowered Rt (2) • The effects of movement restrictions on reducing transmission growth rate declined to 4.41% [IQR 1.0-22.2%] in the third wave (18) • In the post-vaccination period, closing public transport contributes to a lower average daily growth rate (wADGR) of 0.42% compared to no measure of restrictions on public transport (27)
		Serious (n=3) (5; 38; 41)	• For every one-level increase of strictness in closing public transportation ("no restrictions" to "require closing or prohibit most citizens from using it"), the spread rate decreased approximately by 15.21% daily (5) • Public transport closures have a negligible impact over the entire period of study (first wave) (38) • Closure of public transport had a short-term for impact at 12 days but delivered a small impact of 1.0% in decreasing the daily growth rate (41)
		Critical (n=1) (13)	• Public transport closure had only evidence of a weak association with Rt (13)
	Canceling public events	Moderate (n=1) (2)	• Rt less than one was observed in countries that either canceled public events or limited the size of gatherings (2)

		Serious (n=2) (38; 41)	• Compared to the reference pre-intervention period, a unit increase in the value of the intensity of canceling public events led to a decrease of about 12% in the number of daily infections 6 weeks after the intervention was implemented (38) • Cancellation of public events operated over a horizon of around 25 days and had decreasing impacts of 3.4% over daily growth rate (41)
		Critical	None identified
Hand hygiene and respiratory etiquette		Moderate	None identified
		Serious	None identified
		Critical	None identified
Cleaning and disinfecting		Moderate	None identified
		Serious	None identified
		Critical	None identified

Other common PHSMs considered	**International travel restrictions**	Moderate (n=5) (2; 18; 27; 35; 36)	• International travel restrictions were the most effective PHSM on reducing transmission growth rate during the first wave, with a median effect of 41.4% [IQR 14.8-46.3%], and was one of the four PHSMs with the highest impacts (>30%) before vaccine implementation, the median effect was 36.0% [IQR 26.3-40.2%] (18)
			• Border control policy was the second most effective PHSM, prohibiting travels from all regions contributed to a 1.48% reduction of average daily growth rate (wADGR) compared to only screening or quarantining the arrivals (27)
			• Relative to no measures being taken, a total border closure reduces Rt by 0.24 [95% CI: -0.50, 0.01], Rt below one was only observed in countries that either implemented quarantine of arriving passengers from high-risk regions early or enacted bans on arrivals (2)
			• Border closures was associated with a weak reduction in the number of new infections (10%; 95% CrI 2% to 21%) (35)
			• Focused on border restrictions, bans on regions was the most durable policy applied in high-income countries, while in low-income countries, less stringent measures of screening and quarantine arrivals were applied the longest (36)
			  o The cumulatively longer maintenance of the border quarantine was significantly associated with lower infections in COVID-19 high-prevalent countries
			  o In medium and high transmission severity countries, those with longer duration of imposing bans on regions showed no suppressing effects but significantly higher COVID-19 incidence

		Serious (n=6) (5; 38; 40; 41; 70)	• For every one-level increase of strictness in international travel restrictions, the spread rate decreased by approximately 8.13% daily (5) • Travel restrictions show one of the highest fluctuations of effectiveness considering all interventions (fraction of effective portfolios 0.03) (40) • International travel controls become effective at reducing incidence about 10 days after their introduction, for a duration of about two and a half weeks, after which they cease to be effective (38)

			• Both public information campaigns and international travel controls were found to deliver negligible impact over the daily growth rate and were therefore difficult to justify based on the global evidence from this study (41) • Ten (8 pre-existing country characteristics and 2 PHSMs) out of 29 factors considered (21 pre-existing country characteristics and 8 PHSMs) were associated with the initial growth of COVID-19, only restrictions on international movements had a relative significance with respect to the initial growth rate, whereas demographic, climatic, and social variables seemed to play a greater role in the initial growth rate of COVID-19 (70)
		Critical (n=3) (13; 31) Milazzo	• In Australia, the effect of border closure (IRR 0.18; 95%CI 0.14-0.22) in South Australia and lockdown (IRR 0.88; 95%CI 0.86-0.91) in Victoria showed a decrease in incidence two weeks after the introduction of these interventions (64) • Border closures did not show strong temporal overlap with epidemic growth across 11 countries evaluated (31) • International travel controls had only evidence of a weak association with Rt (13)
	Domestic travel restrictions	Moderate (n=1) (15)	• In China, one study found that the Wuhan city travel ban slowed the dispersal of infection to other cities by an estimated 2.91 days (95% CI: 2.54-3.29) on average (15)
		Serious (n=3) (5; 38; 41)	• For every one level increase of strictness on domestic travel restrictions, the COVID-19 spread rate decreased by approximately 9.75% daily (5) • Restrictions on internal movement had a negligible impact over the entire event time window (38) • Internal movement restrictions operated over a horizon of around 25 days and had decreasing impacts of 1.9% over the daily growth rate (41)
		Critical (n=1) (9)	• In Spain, regional mobility restrictions and limited indoors seating capacity were not significant covariates in lowering effect on the Rt (9)
	Testing	Moderate (n=2) (27; 28)	• In the second period (October-December 2020), changes from "testing those who both have symptoms and meet specific criteria" to, respectively, "testing anyone showing COVID-19 symptoms" and "open public testing (e.g., "drive-through" testing available to asymptomatic people)" were associated with an average increase in the average daily growth rate (wADGR) of 0.89% and 0.83% (28) • The widespread testing on the public or those with COVID-19 symptoms decreased average daily growth rate (wADGR) by 1.73% and 0.62%, respectively, compared with a policy that only focused on people with symptoms and meet specific criteria (27)
		Serious (n=1) (39)	• In the U.S., one study found that PHSMs such as quarantining, testing, isolation, and contact tracing appear to have had inadequate coverage and adoption during the infectious periods, limiting their effectiveness at reducing SARS-CoV-2 transmission in the community (39)
		Critical (n=1) (13)	• Testing had evidence of a weak association with Rt (13)
		Moderate	None identified

	Public information campaigns/risk communication	Serious (n=2) (40; 41)	• Risk communication was effectively linking all PHSMs directly or indirectly; the estimated aggregated effectiveness (fraction of effective portfolio) was 0.11, which corresponds to a 22.4% reduction in case growth (40) • Both public information campaigns and international travel controls were found to deliver negligible impact over the daily growth rate and were therefore difficult to justify based on the global evidence from this study (41)
		Critical (n=1) (13)	• Public information campaigns had moderate evidence under the maximum-effort scenario (13)

Table 5: Principal findings of studies reporting on effectiveness of combined PHSMs for reducing COVID-19 associated ICU admissions, ventilation and deaths

Type of PHSM	Operationalization of PHSM	RoB	Principal findings
Quarantine and isolation	Quarantine policies	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Contact tracing strategies	Moderate (n=1) (42)	• No significant effect on reducing deaths attributed to COVID-19 (42)
		Serious	None identified
		Critical	None identified
	Isolation policies	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Workplace policies that support sick days	Moderate	None identified
		Serious	None identified
		Critical	None identified
Masks	Mask mandate or mask requirement	Moderate (n=3) (29; 42; 47)	• Mask-wearing mandates/advisories had neutral initial effects on cumulative mortality, followed by rises in deaths (29) • No significant effect on reducing deaths attributed to COVID-19 (42) • In Switzerland, one study found that the extension of compulsory mask wearing to public places has an heterogeneous impact on mortality, with small positive effects on male mortality entirely driven by older age-cohorts (90+) (47) o Adding contact tracing and stricter distancing to compulsory face-mask policy does not lead to better results in terms of mortality (47)
		Serious (n=1) (16)	• During wave 2, border closures and restrictions to public institutions and mask policies showed inconsistent effects over mortality (16)
		Critical (n=1) (48)	• In Canada, one study found that mask mandates were associated with a 39 log points reduction in the weekly death rate (32% weekly reduction in deaths relative to the trend in absence of mandate) (48)
Ventilation		Moderate	None identified
		Serious	None identified
		Critical	None identified
Physical distancing and reduction of contacts	Physical distancing policies/mandates	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Lockdowns/stay-at-home orders	Moderate (n=3) (29; 42; 43)	• It was identified a tentative change in the trend of COVID-19-related deaths starting around 30 days after strict stay-at-home requirements had been introduced, but this does not exert a statistically significant effect (42)

			• The stay-at-home measures showed an inverted U-quadratic effect with an initial rise of deaths up to Day 20 of the intervention, followed by a decrease (29) • Stay-at-home orders or restrictions on public transport, were not significantly associated with differences in mortality rates across countries (43)
		Serious (n=2) (44; 45)	• Among 57 geographical sites sampled across five continents, the time from SARS-CoV-2 introduction to the time of lockdown (or maximum PHSM in locations that never underwent a full lockdown) was significantly associated with the number of deaths reported at each site 1 month following the time of maximum PHSM in the first wave (R^2= 0.11, p= 0.011) (44) o An additional 14 days of transmission before maximum PHSM was associated with a 2.91-fold [95% CI: 1.35–6.27] increase in deaths 1 month after maximum PHSM in the Deming model and a 2.00-fold [95% CI: 1.19-3.32] increase in the univariate regression (44) • In the U.S., one study found in a linear regression that none of the included policies (stay-at-home orders, school closures, bans on mass gatherings, or closure of non-essential businesses) were associated with a decrease in case fatality rate (CFR) (45)
		Critical (n=2) (23; 46)	• In the U.S., one study found that adopting lockdowns or non-essential business closures 1 day before infections double can curtail the COVID-19 death rate by 1.9% (46) • The largest effect on mortality among PHSMs was observed for stay-at-home orders targeted at risk groups (β=0.24, 95%CI 0.16-0.32) and teleworking (β=0.23, 95%CI 0.15-0.31), followed by enforced stay-at-home orders for the general population (23)
	Gathering restrictions	Moderate (n=3) (29; 42; 43)	• Restriction on gatherings was negatively related to cumulative mortality in four out of nine groups of countries, with coefficients ranging from -6.59 to -14.87, and was positively related to cumulative mortality in five out of nine groups of countries, with coefficients ranging from 7.77 to 41.69; in eight groups coefficients were not statistically significant (42) • Banning mass gatherings had a negative and statistically significant associations with deaths (29) • Only controlling for strictness international travel controls, and only controlling for timing later restrictions on gatherings, were also associated with lower COVID-19 mortality (43)
		Serious (n=1) (45)	• In the U.S., one study found in a linear regression that none of the included policies (stay-at-home orders, school closures, bans on mass gatherings, or closure of non-essential businesses) were associated with a decrease in case fatality rate (CFR) (45)
		Critical	None identified
	Work from home policies/Workplace closure	Moderate (n=2) (42; 43)	• It was identified a tentative change in the trend of COVID-19-related fatalities 30 days after workplaces closure; however, the effects were not statistically different from zero (42) • After adjusting for multiple concurrent interventions and confounders, and accounting for both timing and strictness of interventions, earlier and stricter workplace closure was associated with lower COVID-19 mortality rates (-0.26 daily deaths per million, 95% CI -0.46 -0.05) (43)
		Serious	
		Critical (n=1) (23)	• The largest effect on mortality among PHSMs was observed for stay-at-home orders targeted at risk groups (β=0.24, 95%CI 0.16-0.32) and teleworking (β=0.23, 95%CI 0.15-0.31), followed by enforced stay-at-home orders for the general population (23)

	School closure	Moderate (n=3) (29; 42; 43)	• School closure was negatively related to cumulative mortality in seven out of nine groups of countries, with coefficients ranging from -7.50 to -57.16, but only statistically significant in one group (42) • School closures had negative and statistically significant associations with deaths (29) • After adjusting for multiple concurrent interventions and confounders, and accounting for both timing and strictness of interventions, earlier and stricter school closure was associated with lower COVID-19 mortality rates (-1.23 daily deaths per million, 95% CI -2.20 -0.27) (43)
		Serious (n=1) (45)	• In the U.S., one study found in a linear regression that none of the included policies (stay-at-home orders, school closures, bans on mass gatherings, or closure of non-essential businesses) were associated with a decrease in case fatality rate (CFR) (45)
		Critical	None identified
	Business closures	Moderate (n=2) (29; 42)	• Closure of non-essential business was positively related to cumulative mortality in all nine groups of countries, with coefficients ranging from 1.94 to 21.59, and only in three groups coefficients were not statistically significant (42) • Initial business closures had negative and statistically significant associations with deaths, while a non-significant effect was estimated for non-essential business closures (29)
		Serious (n=1) (45)	• In the U.S., one study found in a linear regression that none of the included policies (stay-at-home orders, school closures, bans on mass gatherings, or closure of non-essential businesses) were associated with a decrease in case fatality rate (CFR) (45)
		Critical (n=2) (46; 49)	• In the U.S., one study found that adopting lockdowns or non-essential business closures 1 day before infections double can curtail the COVID-19 death rate by 1.9% (46) • In India, one study found that the PHSMs that were the most associated with subsequent reductions in mortality were curfews and closure of retail sectors and temples; industry closures, and border closures (49)
	Public transport bans	Moderate (n=1) (42)	• No significant effect on reducing deaths attributed to COVID-19 (42)
		Serious (n=1) (16)	• During wave 2, restrictions on mobility, public transport and healthcare system improvements decreased COVID-19 cases and deaths across all countries (after 49-days), while border closures and restrictions to public institutions and mask policies showed inconsistent effects (16)
		Critical (n=1) (49)	• In India, one study found that transport restrictions were not associated with reductions in deaths (49)
	Cancelling public events	Moderate	None identified
		Serious	None identified
		Critical	None identified
Hand hygiene and respiratory etiquette		Moderate	None identified
		Serious	None identified
		Critical	None identified
Cleaning and disinfecting		Moderate	None identified
		Serious	None identified
		Critical	None identified

Other common PHSMs considered	International travel restrictions	Moderate (n=2) (42; 43)	• No significant effect on reducing deaths attributed to COVID-19 (42) • Only controlling for strictness international travel controls, and only controlling for timing later restrictions on gatherings, were also associated with lower COVID-19 mortality (43)
		Serious (n=1) (16)	• During wave 2, border closures and restrictions to public institutions and mask policies showed inconsistent effects over mortality (16)
		Critical (n=1) (49)	• In India, one study found that the PHSMs that were the most associated with subsequent reductions in mortality were curfews and closure of retail sectors and temples; industry closures, and border closures (49)
	Domestic travel restrictions	Moderate (n=1) (42)	• No significant effect on reducing deaths attributed to COVID-19 (42)
		Serious	None identified
		Critical	None identified
	Testing	Moderate (n=2) (32; 42)	• Total testing showed not effect on cumulative mortality (32) • No significant effect on reducing deaths attributed to COVID-19 (42)
		Serious	None identified
		Critical	None identified
	Public information campaigns/risk communication	Moderate	None identified
		Serious	None identified
		Critical	None identified

Table 6: Principal findings of studies reporting on effectiveness of the combination of PHSMs for reducing transmission of other RIDs

Type of PHSM	Operationalization of PHSM	RoB	Principal findings
Quarantine and isolation	Quarantine policies	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Contact tracing strategies	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Isolation policies	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Workplace policies that support sick days	Moderate	None identified
		Serious	None identified
		Critical	None identified
Masks	Mask mandate or mask requirement	Moderate	None identified
		Serious (n=1) (51)	• Wearing a mask in closed public spaces was found to be independently associated with a reduced bronchiolitis caseload, IRR 0.49 [95% CI 0.25; 0.94, p=0.034] (51)
		Critical	None identified
Ventilation		Moderate	None identified
		Serious	None identified
		Critical	None identified
Physical distancing and reduction of contacts	Physical distancing policies/mandates	Moderate	None identified
		Serious	None identified
		Critical (n=1) (55)	• After the relaxing of the physical distancing policy, the number of patients with respiratory virus (other than COVID-19) significantly increased; the total number of ARI inpatients increasing trends was 0.263 ($p < 0.001$) (55)
	Lockdowns/stay-at-home orders	Moderate	None identified
		Serious (n=2) (51; 52)	• The estimation of the Incidence Rate Ratio showed that full lockdown, IRR 0.21 [95% CI 0.14; 0.30, $p<0.001$] was one of the two PHSMs with the strongest independent protective effect against bronchiolitis (51) • Stay-at-home requirements was negatively associated with the difference between observed and expected RSV positivity rate (-2.86, $p = 0.01$) (52) • Lifting stay-at-home requirements was associated with an absolute increase of 2.27% ($p = 0.06$) in the deviation from expected RSV activity (52)
		Critical	None identified

	Gathering restrictions	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Work from home policies	Moderate	None identified
		Serious (n=1) (51)	• Work from home was found to be independently associated with a reduced bronchiolitis caseload, IRR 0.55 [95% CI 0.31; 0.97, p=0.038] (51)
		Critical	None identified
	School closure	Moderate	None identified
		Serious (n=3) (51-53)	• The estimation of the Incidence Rate Ratio showed that secondary-school closure (IRR 0.33, 95%CI [0.20; 0.52], p<0.0001) was one of the two PHSMs with the strongest independent protective effect against bronchiolitis (51) • School closures was negatively associated with the difference between observed and expected RSV positivity rate (-1.57, p = 0.01) (52) ○ Reopening schools was associated with an absolute increase of 1.31% (p = 0.04) in the deviation from expected RSV activity (52) • For each step increase in school closings 4 weeks before the expected influenza season, the risk of having an influenza season between January 2020 and June 2021 dropped by 43% [IRR: 0.57, 95% CI: 0.34-0.95, p = 0.03] (53)
		Critical	None identified
	Business closures	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Public transport bans	Moderate	None identified
		Serious (n=1) (52)	• Public transport closures were negatively associated with the difference between observed and expected RSV positivity rate (-1.73, p = 0.06) (52)
		Critical	None identified
	Cancelling public events	Moderate	None identified
		Serious (n=1) (53)	• For each step increase in canceling public events (i.e., no measures, recommend canceling locally/nationally, and require canceling locally/nationally), the average percent positivity across the influenza season decreased by 44% [RPR: 0.56, 95% CI: 0.39-0.82, p = >0.01] compared with baseline (no PHSMs) (53)
		Critical	None identified
Hand hygiene and respiratory etiquette		Moderate	None identified
		Serious	None identified
		Critical	None identified
Cleaning and disinfecting		Moderate	None identified
		Serious	None identified
		Critical	None identified
		Moderate	None identified

Other common PHSMs considered	International travel restrictions	Serious	None identified
		Critical	None identified
	Domestic travel restrictions	Moderate	None identified
		Serious (n=1) (52)	• Restrictions of internal movements was negatively associated with the difference between observed and expected RSV positivity rate (-1.33, p = 0.04) (52)
		Critical	None identified
	Testing	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Public information campaigns/risk communication	Moderate	None identified
		Serious	None identified
		Critical	None identified

Table 7: Principal findings of studies reporting on the negative effects of the combination of PHSMs on mental wellbeing and excess of mortality

Type of PHSM	Operationalization of PHSM	RoB	Principal findings
Quarantine and isolation	Quarantine policies	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Contact tracing strategies	Moderate (n=1) (57)	• Contact tracing was negatively associated with mental wellbeing by about - 0.22 [95% CI: - 0.36 to - 0.08] points in terms of WHO-5 score (57) o Negative effects on mental wellbeing were more pronounced in some groups of population, namely, women; those with non-tertiary education; those aged 18-29 or 30-44; those not living with a partner; those living with children aged under 12 years and those living with children between 12 and 17 years (57)
		Serious	None identified
		Critical	None identified
	Isolation policies	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Workplace policies that support sick days	Moderate	None identified
		Serious	None identified
		Critical	None identified
Masks	Mask mandate or mask requirement	Moderate	None identified
		Serious	None identified
		Critical	None identified
Ventilation		Moderate	None identified
		Serious	None identified
		Critical	None identified
Physical distancing and reduction of contacts	Physical distancing policies/mandates	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Lockdowns/stay-at-home orders	Moderate (n=1) (58)	• Associations of stay-at-home requirements with anxiety and depressive symptoms were stronger among males (58)
		Serious (n=2) (60; 61)	• In Australia, one study applying difference-in-differences estimation showed a small but statistically significant effect of lockdown on MHI-5 scores, with greater decline for residents of Victoria in 2020 (exposed earlier to the lockdown) than for those in the rest of Australia (difference 1.4 points [95% CI 1.7 to 1.2]) (60) o Stratified analyses showed that the lockdown effect was larger for females (-2.2 points [-2.6 to -1.7]) than for males (-0-.6 [-0.8 to -0.5]), and even larger for women in couples with children younger than 15 years (-4.4 points [-5.0 to -3.8]), and for females who lived in flats or apartments (-4.1 points [-5.4 to -2.8]) or semi-detached houses, terraced houses, or townhouses (-4.8 points [-6.4 to -3.2]) (60)

			• In the U.S., one study found that in regions with lockdowns, the usage of mental health services increased more than in regions without it, and that patients diagnosed with panic disorders and reaction to severe stress were significantly more affected by the lockdowns (61) o Life management difficulty patients doubled in regions with stay-at-home orders but increased less with school closures (61) o Attention-deficit hyperactivity patients declined in regions without stay-at-home orders (61) o Patients older than 80 used mental health resources less in regions with lockdowns (61) o Adults between (21 - 40) years old were exposed to the greatest lockdown effect with increase between 20% to 30% in regions with lockdown (61)
		Critical	None identified
	Gathering restrictions	Moderate (n=1) (58)	• Associations of restrictions on the size of gatherings with anxiety and depressive symptoms were stronger among females (58)
		Serious (n=1) (57)	• Restrictions on private gatherings were negatively associated with mental wellbeing by about - 0.24 [95% CI: - 0.38 to - 0.10] points in terms of WHO-5 score (57) o Negative effects on mental wellbeing were more pronounced in some groups of population, namely, women; those with non-tertiary education; those aged 18-29 or 30-44; those not living with a partner; those living with children aged under 12 years and those living with children between 12 and 17 years (57)
		Critical	None identified
	Work from home policies	Moderate (n=1) (58)	• Workplace closures were not associated with either anxiety or depressive symptoms in females or males (58)
		Serious	None identified
		Critical	None identified
	School closure	Moderate (n=1) (58)	• Associations of school closures with anxiety and depressive symptoms were stronger among females (58)
		Serious	None identified
		Critical	None identified
	Business closures	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Public transport bans	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Cancelling public events	Moderate (n=1) (58)	• Associations of cancellation of public events with anxiety and depressive symptoms were stronger among females (58)
		Serious	None identified
		Critical	None identified
Hand hygiene and respiratory etiquette		Moderate	None identified
		Serious	None identified
		Critical	None identified

Cleaning and disinfecting		Moderate	None identified
		Serious	None identified
		Critical	None identified
Other common PHSMs considered	International travel restrictions	Moderate (n=1) (58)	• Associations of international travel controls with anxiety and depressive symptoms were stronger among males (58)
		Serious (n=1) (57)	• Restrictions on international travelling were negatively associated with mental wellbeing by about - 0.63 [95% CI: - 0.79 to - 0.47] points in terms of WHO-5 score (57) o Negative effects on mental wellbeing were more pronounced in some groups of population, namely, women; those with non-tertiary education; those aged 18-29 or 30-44; those not living with a partner; those living with children aged under 12 years and those living with children between 12 and 17 years (57)
		Critical	None identified
	Domestic travel restrictions	Moderate (n=1) (58)	• Associations of restrictions on internal movement with anxiety and depressive symptoms were stronger among females (58)
		Serious	None identified
		Critical	None identified
	Testing	Moderate	None identified
		Serious	None identified
		Critical	None identified
	Public information campaigns/risk communication	Moderate	None identified
		Serious	None identified
		Critical	None identified

Figure 1: PRISMA chart

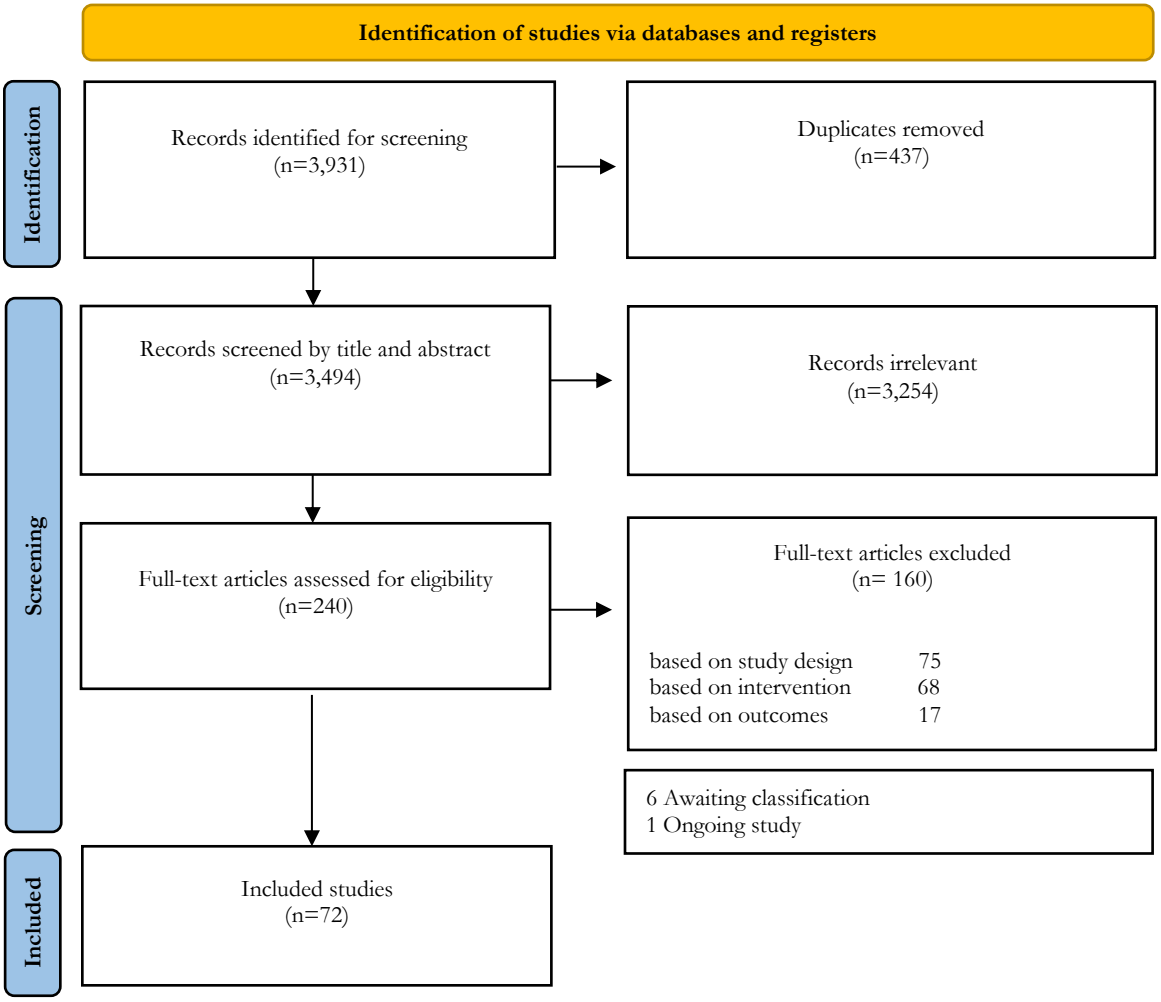
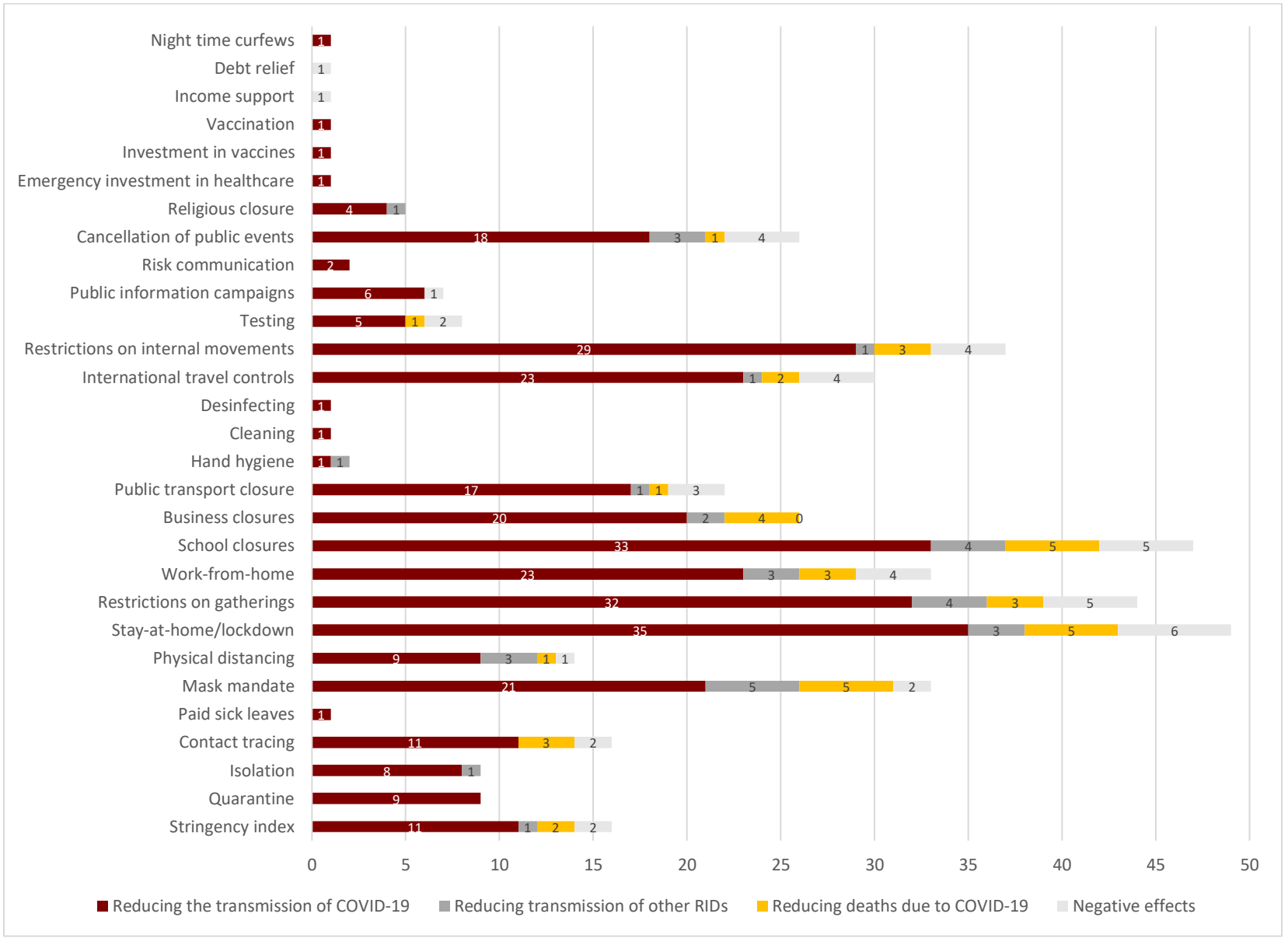


Figure 2: Number of studies assessing each PHSM by outcome



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Appendix 1: Detailed search strategy

Appendix 2: Characteristics and findings of studies included

Appendix 3: Studies excluded at the last stages of reviewing

Appendix 4: List of included studies

Appendix 5: Risk-of-bias assessments for articles included in the synthesis

Appendix 6: Details of studies included in the synthesis

Appendix 7: Reporting periods for studies included in the synthesis

Appendix 8: Data extraction form

Appendix 9: Approach to critical appraisal