

Systematic review of interventions to promote the performance of physical distancing behaviours during pandemics/epidemics of infectious diseases spread via aerosols or droplets

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Conflicts of interest

AK and JD participate in the UK's Scientific Advisory Group for Emergencies sub-groups SPI-B but are writing in a personal capacity.

Abstract

Objectives

Physical-distancing (i.e., keeping 1-2m apart when co-located) can prevent cases of infectious-diseases spread by droplets/aerosols (i.e. SARS-COV2). Distancing is a recommendation/requirement in many countries. This systematic-review aimed to determine which interventions and behaviour change techniques (BCTs) are effective in promoting adherence to physical-distancing and through which potential mechanisms of action (MOAs).

Methods

Six databases were searched for studies of physical-distancing interventions. A narrative synthesis included any design that included a comparator (e.g., pre-intervention versus post-intervention; randomised controlled trial), for any population and year. Risk-of-bias was assessed using the Mixed Methods Appraisal Tool. BCTs and potential MoAs were identified in each intervention..

Results

Six papers of moderate/high quality indicated that distancing interventions could successfully change MoAs/behaviour. Successful BCTs (MoAs) included feedback on behaviour (e.g., motivation); information about/ salience of health consequences (e.g., beliefs about consequences) and demonstration (e.g., beliefs about capabilities) and restructuring the physical environment (e.g., environmental context and resources). The most promising interventions were proximity buzzers, directional systems and posters with loss-framed messages that demonstrated the behaviours.

Conclusions

High quality RCTs that measure behaviour, have representative samples and specify/test a larger range of BCTs /MoAs are needed.

KEYWORDS: *Systematic review; physical distancing; COVID-19; social distancing*

Systematic review of interventions to promote physical distancing behaviours during pandemics/epidemics of infectious diseases spread via aerosols or droplets

The risk of spreading SARS-COV2 (the virus that causes COVID-19) is particularly high when people are in the same location (CDC, 2020). Physical distancing¹ (i.e., staying at least 1-2m apart from people when co-located)², reduces the risk of infection from aerosols and droplets entering the eyes, nose or mouth when an infected person talks, coughs or sneezes (CDC, 2020). Indeed, one review found that SARS-COV2 transmission is reduced with physical distancing of 1m or more compared with closer than 1m (Chu et al., 2020).

Many governments and health agencies have recommended people adhere to a physical distance of between 1m (WHO, 2020) and 2m (NHS, 2021) from people who are not in their household. Desirable spatial distance varies considerably across social and environmental contexts (e.g., familiarity of person, standing vs. seated, indoors vs outdoors) despite the desirability of personal space (Sommer, 1969). For example, typical social interaction happens at an average of 135.1 cm for formal interaction and 91.7 cm for interaction with friends (Sorokowska et al., 2017) and in many interaction contexts, particularly with those people that one feels psychologically close to, proximity is sought, not avoided (Novelli et al., 2010).

Levels of adherence to physical distancing regulations during the Covid pandemic have been varied; between 30.4% and 94.6% of people surveyed reported keeping a physical distance from others (Dohle et al., 2020; Nivette et al. 2021; Norman et al., 2020; ONS, 2021) with differences between countries and contexts (e.g., outdoors vs. indoors; government messaging; infection levels; Reinders Folmer et al., 2020). It is therefore

¹ Many governments use the term ‘social distancing’, but the World Health Organization recommends the term ‘physical distancing’ as more accurate

² The precise distance recommended varies across different countries.

important to understand what influences, and how to influence distancing behaviours in order to design effective behaviour change interventions (see O'Connor et al., 2020).

To design effective behaviour change interventions it is important to identify what needs to change (i.e., a domain/construct derived from theoretical frameworks / theories e.g., from the theoretical domains framework, TDF, Cane et al., 2012; Michie et al., 2014); the means by which to change it (i.e., the intervention function; policy category), which technique to use (i.e., the behaviour change technique – BCT), and how to deliver that BCT. For the target behaviour of physical distancing a relevant domain to target could be *social influences* (i.e., interpersonal processes that can influence cognitive, affect and behaviour); within this a relevant theoretical construct is *social norms*; this can be changed by targeting the intervention function of *modelling* (i.e., providing examples for people to emulate); using the BCT of *demonstration of the behaviour*; and delivered by a poster showing two people distancing using the length of a car to ensure they are 2m apart.

Longitudinal survey studies (Hagger et al., 2020; Hamilton et al., 2020; Norman et al., 2020; Rozendaal et al., 2020; Van Bavel et al., 2020; Vignoles et al., 2021) and guidance documents / recommendation papers (e.g. Bonell et al., 2020; Drury et al., 2021; SPI-B, 2020; Templeton et al., 2020) have identified several predictors that are associated with the theoretical domains of social influences, beliefs about capability, beliefs about consequences, behavioural regulation, and knowledge. These predictors influenced subsequent physical distancing behaviour. The studies have proposed BCTs (e.g., social approval, framing/reframing, feedback on behaviour, restructuring the physical environment; information about health consequences, salience of health consequences, habit formation, prompts and cues) that could be used in interventions (Hagger et al., 2020; Hamilton et al., 2020; Norman et al., 2020; Rozendaal et al., 2020). However, to identify

relevant theoretical domains, intervention functions, policy categories and determine which BCTs are effective, interventions that allow comparisons between the presence and absence of intervention components are needed.

It is also important, after intervention, to identify the potential Mechanisms of Action (MoAs) that BCTs might affect (Moore & Evans, 2017; Carey et al., 2019) to explain how the intervention works. The theory and techniques tool (Carey et al., 2019; Connell et al., 2018; Johnston et al., 2020) was developed from a synthesis of the literature, consensus and triangulation studies to determine whether a BCT works through that MoA and the strength of that evidence.

The present study

Although the survey evidence identifies potential theoretical domains and BCTs to target and potential behaviour change techniques through associations with cross-sectional or longitudinal outcomes, we do not know (a) if interventions are effective at promoting the performance of physical distancing during a pandemic, (b) what the most effective components are of interventions (e.g., behaviour change techniques; modes of delivery), (c) what are the likely theoretical domains, intervention functions and MoAs, (d) who the interventions are effective for and (e) in which circumstances the interventions work best (e.g., phase of pandemic; other restrictions e.g., lockdown; infection rate; case fatality ratio). A systematic review of interventions was conducted and assessed the methodological quality/risk of bias of the studies in order to weight the strength of the evidence.

Methods

The review was pre-registered on PROSPERO ([CRD42021230821](https://doi.org/10.1111/1471-2575.15421)).

Search strategy and selection criteria

Searches for published and unpublished studies were performed on six databases between January to February 2021 using PubMed, PsycInfo, Web of Science³, PsyArXiv, MedRXiv and the Open Science Framework with no restriction on date. Search filters used were for behaviour (e.g., physical distancing, social distancing), study type (e.g., intervention, trial or experiment) and virus related (e.g., COVID, coronavirus, SARS, MERS, H1N1, Ebola, influenza or swine flu pandemic, epidemic). See Supplementary materials for full search terms. Additional studies were located using ascendancy (using google scholar) and descendancy approaches.

Studies were included if they (a) reported interventions to promote physical-distancing (i.e., those that focus on distancing when people are co-located in the same physical space e.g., keeping at least 1-2m apart), (b) included any human population, (c) included any comparator (e.g., pre-intervention behaviour, alternative intervention, a control group, a measurement only group), (d) were any study design (e.g., randomised controlled trials; pre-post studies; non randomised controlled trials; natural experiments), (e) in any setting, (f) for any date and (g) reported performance of physical-distancing behaviour (e.g., observational measures of number of people distancing vs not distancing; self-reported frequency or quality of distancing behaviour), a predictor of behaviour (i.e., a MoA / theoretical construct or variable that may influence behaviour: e.g., self-efficacy, intentions, willingness, attitudes, norms) or outcomes of behaviour (e.g., number of infections, mortality data).

³ This includes: Science Citation Index Expanded (1900-present) -- Social Sciences Citation Index (1900-present) -- Arts & Humanities Citation Index (1975-present) -- Conference Proceedings Citation Index- Science (1990-present) -- Conference Proceedings Citation Index- Social Science & Humanities (1990-present) -- Book Citation Index-- Science (2005-present) -- Book Citation Index-- Social Sciences & Humanities (2005-present) -- Emerging Sources Citation Index (2015-present) -- Current Chemical Reactions (1993-present) (Includes Institut National de la Propriete Industrielle structure data back to 1840) -- Index Chemicus (1993-present)

Screening

Each reference was screened by two authors using Rayyan referencing software. At the title/abstract screening stage any that were marked as 'include' by at least one screener were reviewed at the full text stage. Any that were marked 'maybe' by at least one screener were further assessed by the first author who decided whether to include for the full text stage. Full texts were screened by two additional authors (XX, YY) and disagreements were resolved through discussion with the two authors (there was 17% disagreement in the full texts).

Data extraction

Data were extracted by the first author using a coding frame (see Table 1) developed by two authors (XX, YY – both had PhDs in Psychology). For each study, the following were recorded: study type (e.g. randomised controlled trials; pre-post studies; non randomised trials; natural experiments); context (e.g., country of data collection, date of data collection, public health restrictions in place at the time, phase of the pandemic); sample (e.g., *N*, population, gender, age); intervention description (e.g., setting, description of delivery); comparison (e.g., type of control or alternative intervention, description of delivery, BCTs and a summary of the findings (including effect sizes and whether measure of distancing was indoors or outdoors)).

BCTs were identified using the BCTTv1 (Michie et al., 2013) which is a 93-item taxonomy of behaviour change techniques that is widely used in describing interventions. The theoretical domains were identified using the results of an expert consensus study (Cane et al., 2015) and intervention functions were identified using a review of interventions (Michie et al., 2014) and an expert consensus exercise (Michie et al., 2014). The policy categories MoAs related to each BCT were identified using the Theory and Technique tool

(Carey et al., 2019; Connell et al., 2018; Johnston et al., 2020) which is an atheoretical list of MoAs that are linked to BCTs. Policy categories were identified using the behaviour change wheel definitions (Michie et al., 2014).

Risk of bias was assessed using the MMAT⁴ (Hong et al., 2018). The tool uses two screening questions on the research question and suitability of data collection with five follow up questions depending on design (see Table 2). The summary of findings, effect sizes, BCTs, and risk of bias were checked by a second data-extractor (WW, XX, YY or ZZ). Authors were contacted for missing information.

Results

The flow of papers is shown in Figure 1 (Page et al., 2021). Potentially relevant articles were identified from the database search ($N = 1146$) and 1 article was obtained from other sources. Titles and abstracts ($N = 1014$) were screened for eligibility after removing 133 duplicates; screening was conducted by 18 authors (all with a PhD and/or MSc in psychology). Studies that did not meet the inclusion criteria ($N = 956$) were excluded, leaving 59 articles for which full texts were obtained and read. A further 53 articles were excluded after the full text was examined; the principal reason for exclusion at this stage were that no intervention to promote physical distancing occurred ($N = 47$). The remaining articles ($N = 6$) met the inclusion criteria for the review, reporting tests of the impact of physical distancing interventions on behaviour or predictors of behaviour.

Study characteristics

⁴ Low quality was categorised as 0-1; moderate quality was categorised as 2-3; and high quality was categorised as 4-5.

The six papers that met the inclusion criteria reported the effect of 14 interventions (and three other control interventions) and included over 5531 participants⁵. The studies included randomised controlled trials (Bos et al., 2020; Khoa et al., 2021; Lunn et al., 2020); non-randomised trials (Blanken et al., 2020; Chutipimon et al., 2020); and a natural experiment (Hoeben et al., 2021).

Studies were based in Europe (Bos et al., 2020; Blanken et al., 2020; Hoeben et al., 2021; Lunn et al., 2020), Asia (Chutipimon et al., 2020); and North America (Khoa et al., 2021). Data were collected between January - August 2020 (See Table S1). Study samples were taken from the general population (Bos et al., 2020; Hoeben et al., 2021; Khoa et al., 2021; Lunn et al., 2020); university staff, students, graduates and visitors (Blanken et al., 2020; Chutipimon et al., 2020)

Interventions included: instructional message, delivered online from a medical professional, focused on health consequences (Bos et al., 2020); instructional message, delivered online from a medical professional, focused on moral duty (Bos et al., 2020); decal stickers (i.e. a design on durable stickers) on floors to show recommended distance (Chutipimon et al., 2020); government recommendation to keep a 1.5m physical distance from people not in your household (Hoeben et al., 2021); government fines in the event of not adhering to the mandated 1.5m physical distance from people not in your household (Hoeben et al., 2020); instructional posters demonstrating distancing behaviour (control poster – Lunn et al., 2020); posters demonstrating violations of 2m distancing with implied health consequences (Lunn et al., 2020); images demonstrating physical-distancing (Khoa et al., 2021); one-way system (Blanken et al., 2020); and buzzers to indicate proximity

⁵ One study (Hoeben et al., 2021) did not report the N due to the nature of the observational study design

violations (Blanken et al., 2020). Interventions were mainly set online (Bos et al., 2020; Khoa et al., 2021; Lunn et al., 2020); in semi-public spaces (Blanken et al., 2020; Chutipimon et al., 2020); public spaces (Hoeben et al., 2021). See Table 1 for full description of studies.

Risk of bias

Six studies were classified as moderate quality (between 40% and 60%) and one study was categorised as high quality (80%). See Table 3 for breakdown of risk of bias.

Main results

Legislation

Government recommendations

One study, from Netherlands, explored distancing pre and post government distancing recommendations (Hoeben et al., 2021). A natural experiment used CCTV footage of open public spaces and compared footage from dates that were pre government recommendations (29 February – 12 March 2020) and post government recommendations (after 15 March). Counts of distancing violations started to decline from 12 March even though no explicit distancing recommendation was in place and continued to decline after the government recommendation on the 15 March until the 19 March. There was not strong evidence the explicit government recommendations influenced distancing behaviour as this was already occurring pre recommendation (Hoeben et al., 2021).

Government fines

Hoeben et al. (2021) also measured distancing behaviour, in their natural experiment, after government fines were announced for non-compliance (of breaching the 1.5m rule and meeting in groups of three or more) by comparing pre fine and post fine CCTV footage (after 23 March 2020). After the government fines were introduced there was a steady increase in distancing violations from early April to early May (especially on

weekends) – this was correlated with the increased number of people on the street (from CCTV footage) and increased number of people in non-residential locations (from cell phone data) (Hoeben et al., 2021). There is no evidence that government fines influenced distancing behaviour.

Environmental Restructuring

Directional Systems

A non-randomised trial tested the implementation of one-way systems on distancing behaviour (Blanken et al., 2020). One-way floor decal arrows were used to indicate walking directions at an art fair and behaviour was measured using proximity sensors worn by visitors. One set of comparisons included comparing one-way arrows versus no arrows (both conditions also included a buzzer that sounded when within 1.5m proximity of another person). The addition of one-way arrows decreased the number of distancing violations ($d = .40$). However, a further comparison of one-way arrows versus bi-directional arrows (two lanes – clockwise and anti-clockwise) found that there was no difference between the two conditions with slightly fewer violations in the bi-directional arrow condition ($d = -.13$).

Distancing Markers

An observational study of behaviour in a university canteen over four separate days explored the effectiveness of floor decal stickers that marked out 2m distances (2 side by side at the canteen counter and 3 adjacent to the counter) (Chutiphimon et al., 2020). A red arrow between footprint stickers at 2m distances (to show the direction to queue; $d = .10$); an image of an aggressive red “scary” COVID-19 with glowing eyes and “Stop COVID-19” printed under it with cut-outs for feet at 2m distances ($d = .22$) or written message between footprint settings of (e.g., “Physical distancing and Win COVID-19”, “Please maintain a distance from other customers” and “Please queue here”) ($d = -.11$) were not significantly

more effective overall than the footprint stickers alone (Chutipimon et al., 2020). The written message was significantly more effective than the footprint stickers alone at one of the marking points near the counter ($d = .52$) but not at the other (Chutipimon et al., 2020). With all groups there were fewer violations of distancing at markings further away from the counter (Chutipimon et al., 2020).

Proximity indicators

A non-randomised trial tested the use of buzzers (i.e., a device that buzzed when within 1.5m of another person) on distancing behaviour (Blanken et al., 2020). The buzzer was effective in reducing distancing violations ($d = .42$) when users received a demonstration of how it worked and the buzzer sounded immediately when within the 1.5m range compared to a condition without buzzers. The buzzers were ineffective when there was a 2-second delay in buzzing after being within the 1.5m range ($d = -.22$).

Communication/ Marketing

Written messages

A large scale randomised controlled trial ($N = 3616$) found that a brief written message delivered online, from a credible source (i.e. medical professional), about the health consequences of not physical-distancing was not effective in increasing intentions to physically distance ($d = .06$) but did increase support for government regulations ($d = .10$) compared to a no message control (Bos et al., 2020). A brief written message, from a credible source, focusing on the moral duty to physically distance was effective in increasing intentions to physical distance ($d = .10$) and for support for government regulations ($d = .13$) compared to a no message control (Bos et al., 2020). However, there were no differences between the health consequences and the moral duty message and no data about the impact of the intervention on subsequent behaviour.

Posters

Two randomised controlled experiments found that a poster with an image of two featureless figure cartoons standing a distance apart with a two-way arrow between that included a message focused on showing how the behaviour steers away from negative outcomes (i.e., a loss framed message - “failing to maintain physical distance risks yourself of being infected with the coronavirus and endangers your personal life”) was more effective at increasing intentions to physically distance⁶ than the same picture with a message to “please maintain physical distance” (Khoa et al. – study 2, 2021), and the same picture with a message focused on positive outcomes (i.e., a gain framed message - “Maintaining physical distance protects yourself from being infected with the coronavirus and secures your personal life”) (Khoa et al. – study 2, 2021; Khoa et al., - study 3; $d = .59$). There were no differences in self-efficacy between the loss framed and the gain framed poster. The loss framed message also increased fear more than the gain framed message and fear mediated the effect of the intervention on intentions (Khoa et al. – study 2, 2021).

The addition of an anthropomorphic image of a COVID-19 virus to the gain framed and loss framed message also resulted in increased intentions with a loss framed message compared to the gain framed message (Khoa et al., - study 3, 2021; $d = 1.76$). None of the studies measured impacts on behaviour.

An online randomised experiment compared three posters: (a) an instructional poster that included four panels with images of two featureless figure cartoons at a 2m distance apart in four situations (i.e., walking in the street, sitting at a table, when shopping, on a

⁶ This was a 4 item measures that included “likelihood of avoiding crowded areas in supermarket”; “keeping myself physically distant from others while shopping”; “maintaining a safe distance from people in supermarket”; and “keep myself apart from engaging in touching of others whilst shopping”

football field); (b) individual people referred to regarding transmission of the virus (i.e., four panels showed groups of people not physically distancing with comments referring to one person who “Has COVID-19 but doesn’t know it yet” and the implied consequences of this “Has an undiagnosed heart condition. If they had sat further apart, she’d have been ok”); and (c) transmission rate without referring to individual people (i.e., four panels showed groups of people not physically distancing with comments referring to a person who “Has COVID-19 but doesn’t know it yet” and the implied consequences of this “Will now pass the virus onto 6 others. If they had sat further apart, she’d have been ok”). The featureless figure poster was perceived as more effective ($d = -.32$) and memorable ($d = -.37$) than the individual people transmission poster (Lunn et al., 2020) but not the transmission rate only poster ($d = -.15$ for effectiveness; $d = -.23$ for memorability); there were also no differences between the transmission rate and the individual person posters ($d = .17$ for effectiveness; $d = .14$ for memorability; Lunn et al., 2020). However, the perceived effectiveness and memorability of posters does not necessarily reflect behaviour change.

BCTs and MoAs

Feedback on behaviour (2.2) was effective although the unique effect of this was not tested (Blanken et al., 2020). Information about health consequences (5.1) were effective when using a brief loss framed message on a poster demonstrating the behaviour (6.1) (Khoa et al., 2021) and when a moral duty poster was compared with a measurement only control (Bos et al., 2020). They were ineffective with a message focused on avoiding consequences from a credible source (health consequences - Bos et al., 2020); a gain framed message focused on gaining positive outcomes (Khoa et al., 2021) and posters showing transmission routes (Lunn et al., 2020). Salience of consequences (5.2) was effective when

using a COVID on a loss framed poster that demonstrated the behaviour (6.1) (Khoa et al., 2021) but not when it was used to separate 2m floor decals (Chutipimon et al., 2020).

Demonstration of the behaviour (6.1) worked with a brief loss framed message to increase intentions (Khoa et al., 2021). Demonstration of the behaviour (6.1) and instructions to perform the behaviour (4.1) increased perceived effectiveness and memorability of the message (Lunn et al., 2020).

There were inconclusive results for credible source (9.1) as there was no difference between a health consequences message and a control but a moral duty message was effective in influencing intentions (Bos et al., 2020). Government guidelines did not influence actual behaviour (Hoeben et al., 2021).

Comparative imagining of future outcomes (9.3) was not effective in changing perceived effectiveness and memorability (Lunn et al., 2020). Future punishment (10.11) with a government fine was not effective in changing behaviour (Hoeben et al., 2021)

Restructuring the physical environment (12.1) with direction walking systems were effective at increasing physical-distancing (Blanken et al., 2020).

Framing / reframing (13.2) as a moral duty was effective at changing intentions when compared to a control but not to a health consequences message (Bos et al., 2020).

The BCTs and MOAs that are potentially influenced are summarised in Table 2. Table 2 also links each BCT to theoretical domains, intervention functions and policy categories.

Discussion

The current systematic review identified six papers reporting the effects of 14 interventions and provides important guidance for policy makers on possible interventions to promote this key health protective behaviour. The review found support for several BCTs and MoAs involved in physical distancing behaviour. These included interventions that used

BCTs (and targeted MoAs) such as: (2.2) providing feedback on the behaviour (feedback processes; motivation) such as delivered via proximity buzzers (Blanken et al., 2020); (5.1) information about health consequences (to address knowledge; beliefs about consequences; attitudes towards the behaviour; intentions; perceived susceptibility/vulnerability) such as delivered via posters with loss framed messages, with an image of a COVID virus standing between two figures (Khoa et al., 2021); (5.2) salience of consequences (to address beliefs about consequences; perceived susceptibility/vulnerability) such as delivered via posters with loss framed messages, with an image of a COVID virus standing between two figures (Khoa et al., 2021); (6.1) demonstration of the behaviour (beliefs about capabilities; social learning/imitation) such as delivered via posters with loss framed messages, with an image of a COVID virus standing between two figures (Khoa et al., 2021); (12.1) restructuring the physical environment (to change environmental context and resources; behavioural cueing) such as directional systems; (12.5) adding objects to the environment (to change environmental context and resources; behavioural cueing) through proximity buzzers (Blanken et al., 2020).

There was no support for the BCT of future punishment as government fines (Hoeben et al., 2021) were ineffective; this is supported by a recent report suggesting that punitive approaches to public health that tend to be ineffective or counterproductive (Independent SAGE, 2021).

Physical distancing is influenced by the context in which it is performed. For example, distancing is affected by the number of other people in the vicinity (Hoeben et al., 2021; Liebst et al, 2020). Hoeben et al. (2021) noted that stay at home orders facilitated distancing in their study as there were fewer people in public spaces which consequently made physical distancing easier. Interventions that addressed opportunity such as making

structural changes to facilitate the behaviour such as directional systems were effective (Blanken et al., 2020). Distraction may also affect the ability to distance; for example, distancing behaviour decreased when ordering food at the counter (Chutipimon et al., 2020). Those who lived in low risk areas had decreased physical distancing in an avatar study (Cartaud et al., 2020) and higher levels of trust in science and politics also increased adoption of behaviours such as physical distancing (Dohle et al., 2020). There is mixed evidence around wearing a face covering; an avatar study found that when avatars wore masks people indicated they would stand closer (Cartaud et al., 2020; Luckman et al. 2020); however, 1.5m distancing was not related to mask wearing in a CCTV observational study (Liebst et al., 2020).

With reference to the MoAs identified in the literature several were tested in the interventions included in this review. Successful interventions that potentially influenced attitudes towards the behaviour were posters with loss framed messages, with an image of a COVID virus standing between two figures (Khoa et al., 2021) and that emphasised the moral to break the chains of infection (but only when compared to a control and not the health consequences message; Bos et al., 2020). This latter intervention may have been improved if they had focused on the responsibility to protect high risk groups as adherence to restrictions was related to identification with at risk groups or identification with collective effort protect those in high risk groups (Liekfett et al., 2021).

Beliefs about capability were addressed through posters demonstrating the behaviour (Khoa et al., 2021; Lunn et al., 2020) that were successful in increasing intentions and perceptions of effectiveness and memorability.

Beliefs about consequences and perceived susceptibility/vulnerability were addressed in studies that included health consequences and salience of consequences with mixed results.

Prospect theory (Kahneman & Tversky, 1979) suggests that when trying to change behaviours linked to health risk (e.g., physical distancing), loss frames (e.g., making negative health consequences of not doing behaviour salient) are more effective than gain frames (e.g., making the benefits of doing the behaviour salient) as we are motivated to reduce the loss. This theory was supported as a loss framed message on a poster was more effective in increasing intentions than the same poster with a gain framed message (Khoa et al., 2021). In the Bos et al. (2020) study a gain framed moral duty written message was more effective at influencing intentions than no message. However, the Bos et al. (2020) study had a large sample size, so the effect size was very small; moreover, there were no differences between the moral duty message and the health consequences messages that included both loss and gain framed components (Bos et al., 2020). There is evidence that risk information, such as information about health consequences, should be coupled with efficacy information to increase the effect (Sheeran et al., 2014). However, there was no evidence that including information to increase response efficacy (e.g., mentioning that physical distancing breaks the chains of infection) increased the effectiveness of health consequences information (Bos et al., 2020; Lunn et al., 2020).

This review identified several limitations in the extant literature. First, measures in many studies conflated physical distancing when co-located (e.g., keep 1-2m apart; avoid hugging, kissing, hand shaking) with limiting in person interactions (e.g., avoid crowded places, work from home, limit time spent away from home) – we excluded these studies from our review. Although physical distancing when co-located and limiting in person interactions are related as physical distancing is easier as public spaces are less crowded when people limit time spent away from the home (Hoeben et al., 2021) there are differences between the behaviours. These behaviours are likely to require addressing different MoAs and using

different BCTs. Second, studies did not always report intentions or behaviour; for example, Lunn et al. (2020) reported perceived effectiveness and memorability of the intervention posters but not intentions to distance or actual behaviour. Although measuring these variables is useful when deciding between different posters addressing the same MoA and using the same BCTs it is less useful at early stages of research when identifying effective MoAs and BCTs are needed. An agreed core outcome set could be used to improve reporting standards (Williamson et al., 2021; Shorter et al., 2019). Third, only fourteen out of twenty-six MoAs were coded as included in the interventions in this review and only thirteen out of ninety-three behaviour change techniques were coded by this review's authors (moreover, none of the studies identified behaviour change techniques using a taxonomy). Moreover, these have not always focused on MoAs that have been identified as potentially important, e.g., behavioural regulation was identified as an important target but was not tested in the included interventions (Hagger et al., 2020). Fourth, the interventions did not always compare interventions that differed in BCTs – for example, Chutipimon et al. (2020) compared two interventions that both used prompts and cues (7.1). Although this is useful when deciding the best way to deliver BCTs we know are effective it is less useful when we need to identify effective BCTs. Behavioural regulation, perceived susceptibility/vulnerability and social norms were not addressed in the interventions included in this review. Fifth, the samples were largely unrepresentative of the population.

Further research into interventions to promote physical distancing behaviour is needed; this review has identified which of the MoAs which may be suitable for intervention design. Future interventions could also systematically test the addition of additional BCTs (not considered here). For example, (6.2) social comparison and (6.3) information about others approval could be effective in changing social norms around

physical distancing ; (1.2) problem solving (e.g., finding solutions to address situations when distancing is difficult) and (1.4) instructions on how to perform the behaviour could be effective in increasing capabilities; (5.2) information about social and environmental consequences, (5.5) anticipated regret, and (5.6) information about emotional consequences could influence beliefs about consequences; (1.1) goal setting (outcome) and (10.8) incentive (outcome) (e.g., information about the positive consequences of distancing on allowing opening up of restrictions) could influence intentions and motivation. Studies that explore the barriers and facilitators of physical distancing are also required to ensure the interventions are optimised; for example, a barrier may be that physical distancing involves the co-operation of others so an intervention component that focuses on being able to communicate your distancing needs with others may be necessary.

Regarding limitations of this review. First, there was only one high quality study in the review. Second, we aimed to capitalise on emerging evidence with our search strategy but due to the rapidness of the review we were unable to search more than six databases that may have impacted on the small number of studies. Third, we were not able to meta-analyse the data due to the small number of effect sizes for each outcome and problems with the independence of these effect sizes. Fourth, the small number of studies and the unrepresentative samples meant we were not able to explore who the interventions worked for.

This review is the first review to summarise the state of the literature regarding physical distancing interventions – although the review contains only a small number of studies there is a need to evaluate emerging evidence in order to promote physical distancing during the ongoing COVID-19 pandemic. The review has extended our knowledge to show that physical distancing intentions and behaviour can be increased but the size of the effect

cannot be determined. Although there are BCTs that show influences on intentions and behaviour this is largely based on moderate quality evidence so strong conclusions cannot be drawn; however, this synthesis has provided recommendations for interventions to be tested future research and a starting point for public health campaigns.

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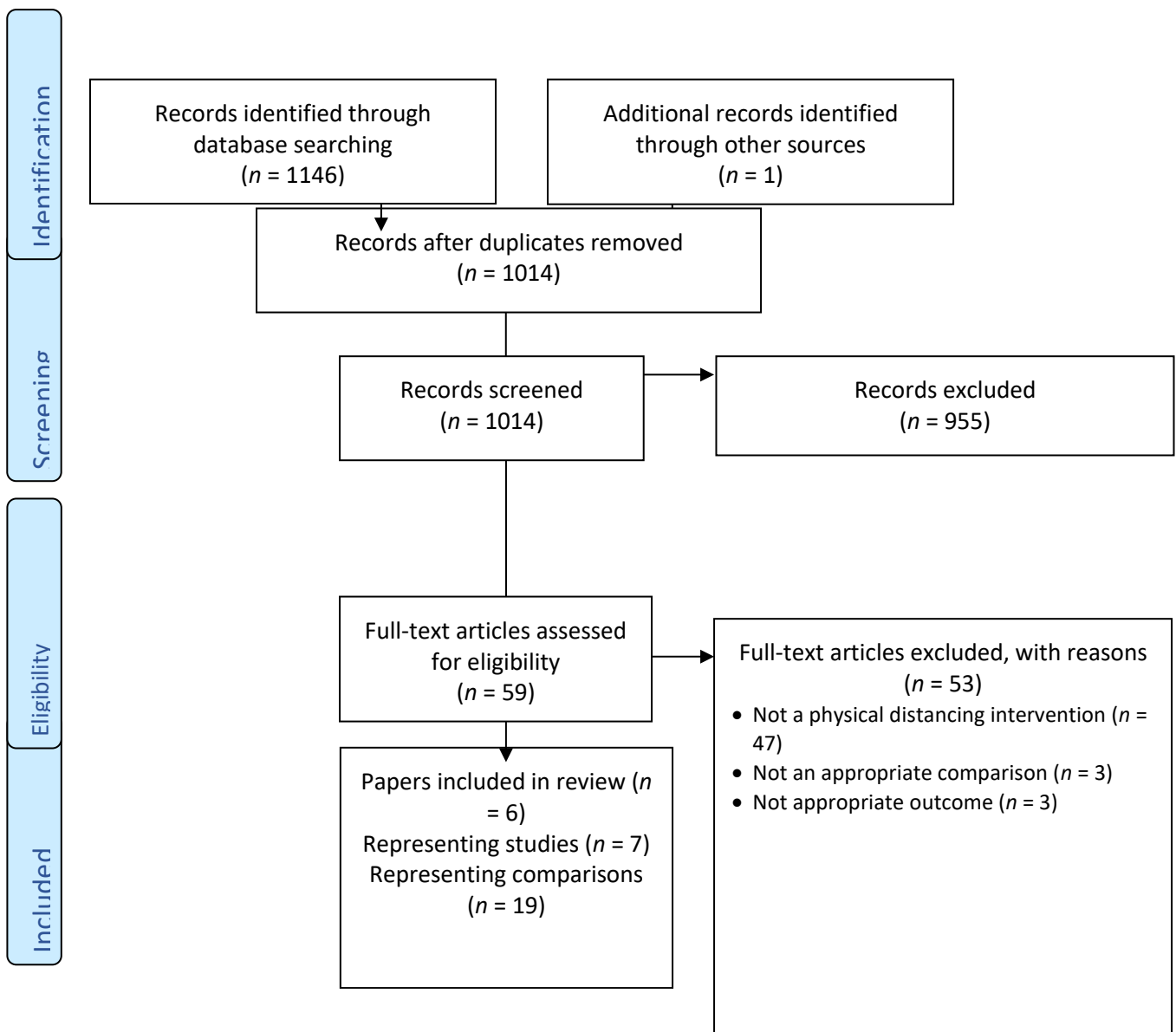


Figure 1. Flow diagram of papers included in the review

Table 1: Study Characteristics

Authors / Study type	Context	Sample description	Intervention description	Comparison	Results
Bos et al. (2020) RCT	<p>Country: Germany</p> <p>Data collection: 20-27 March 2020</p> <p>Public health measures: Nationwide contact ban announced on 22 March that prohibited meeting more than one person at a time outside of HH</p> <p>Does not mention government physical distancing recommendation</p> <p>Phase of pandemic: 19,848 - 50,871 cases 68 – 351 deaths</p>	<p>N: 3616</p> <p>Population: General population</p> <p>Gender: not reported</p> <p>Age: not reported</p>	<p>Setting: online</p> <p>Delivery: Consequentialist message – focus on consequences; included photo of credible source</p> <p><i>“Dr Med Kellner, who is an infectiologist is treating corona patients in Leipzig, appeals to consider the consequences of personal actions: ‘In times of the corona pandemic, the actions of every person can have considerable consequences for the health of other people. Through their personal actions they can break the chain of infection and thus protect especially the weakest in society from illness and death. Think about the consequences of your actions and the suffering of others, which you can prevent by keeping a physical distance from people, paying careful attention to hygiene, and encouraging your fellow humans to do the same.’”</i></p> <p>BCTs: Potentially active 5.1 health consequences* 9.1 credible source</p>	<p>Setting: online</p> <p>Delivery: No message control</p> <p>BCTs: None</p>	<p>Intentions (indoors or outdoors not specified)</p> <p>No effects on plans to physically distance (defined as “situations in which the respondent comes closer than two meters to others”)</p> <p>“Compared to the same week last year, by what percentage will you reduce or increase your physical, social contacts in the coming week?”</p> <p><i>d = .06</i></p> <p>Support for Government regulations</p> <p>Significant difference in support for government regulations particularly in under 60 year olds and women</p> <p><i>d = .10</i></p>
			<p>Setting: online</p> <p>Delivery: Deontological message – focus on moral duty; included photo of credible source</p> <p><i>“Dr Med Kellner, who is an infectiologist is treating corona patients in Leipzig, appeals to the moral duty to stop the pandemic: ‘In times of the corona pandemic, every person has a moral duty to stop the spread</i></p>	<p>Setting: online</p> <p>Delivery: Consequentialist message – focus on consequences; included photo of credible source</p> <p><i>“Dr Med Kellner, who is an infectiologist is treating corona patients in Leipzig, appeals to consider the consequences of personal actions:</i></p>	<p>Intentions (indoors or outdoors not specified)</p> <p>No effects on plans to physically distance (defined as “situations in which the respondent comes closer than two meters to others”)</p> <p>“Compared to the same week last year, by what percentage will you reduce or increase your physical, social contacts in the coming week?”</p>

of the virus. You fulfil your moral duty by keeping a physical distance from people, paying careful attention to hygiene, and encouraging your fellow humans to do the same. Consider to what extent your personal actions are suited to break the chains of infection and whether the pandemic would be contained if everyone acts like you.”

BCTs:
Potentially active
13.2 framing/reframing*†
Also in comparison group
5.1 health consequences
9.1 credible source

Setting: online

Delivery:
Deontological message – focus on moral duty; included photo of credible source

“Dr Med Kellner, who is an infectiologist is treating corona patients in Leipzig, appeals to the moral duty to stop the pandemic:

‘In times of the corona pandemic, every person has a moral duty to stop the spread of the virus. You fulfil your moral duty by keeping a physical distance from people, paying careful attention to hygiene, and encouraging your fellow humans to do the same. Consider to what extent your personal actions are suited to break the chains of infection and whether the pandemic would be contained if everyone acts like you.”

BCTs:
Potentially active
13.2 framing/reframing*
5.1 health consequences
9.1 credible source

‘In times of the corona pandemic, the actions of every person can have considerable consequences for the health of other people. Through their personal actions they can break the chain of infection and thus protect especially the weakest in society from illness and death. Think about the consequences of your actions and the suffering of others, which you can prevent by keeping a physical distance from people, paying careful attention to hygiene, and encouraging your fellow humans to do the same.”

BCTs:
Potentially active
None
Also in intervention
5.1 health consequences
9.1 credible source

Setting: online

Delivery:
No message control

BCTs:
None

$d = .04$

Support for Government regulations

No difference in support for government regulations

$d = .03$

Intentions (indoors or outdoors not specified)

Significant difference in plans to physically distance (defined as “situations in which the respondent comes closer than two meters to others”)

$d = .10$

This message is particularly effective for those under 60 and males
“Compared to the same week last year, by what percentage will you reduce or increase your physical, social contacts in the coming week?”

Support for Government regulations

Significant difference in support for government regulations particularly in under 60 year olds and women

$d = .13$

Blanken et al. (2020)	<p>Country: Netherlands</p> <p>Data collection: Data collected 28-30 August 2020 at an Art Fair between first and second wave of COVID-19 (about 500 cases per day)</p> <p>Public health measures: 9 March & 12 March directives (e.g., avoiding hand shaking, working from home) 15 March 1.5m recommended</p> <p>23 March fines for not adhering to 1.5m rule</p> <p>Phase of pandemic: 69,131 – 70,140 cases 6,224 deaths</p>	<p>N: 787</p> <p>Population: Graduates of Dutch art academies and others</p> <p>Gender: not reported</p> <p>Age: not reported</p>	<p>Setting: Art fair</p> <p>One way system:</p> <p>Delivery: Walking directions unidirectional with arrows on floor decals (one lane only)</p> <p>Buzzer when within 1.5m of another person (not from your HH) – immediate buzzing after contact was made (and demonstration of how it worked)</p> <p>BCTs: Potentially active 12.1 restructure physical environment* 12.5 Adding objects to the environment Also in comparison group 2.2 Feedback on behaviour 7.1 prompts and cues</p>	<p>Setting: Art fair</p> <p>Delivery: Buzzer when within 1.5m of another person (not from your HH) – immediate buzzing after contact was made (and demonstration of how it worked)</p> <p>BCTs: Also in intervention 2.2 Feedback on behaviour 7.1 prompts and cues 12.5 Adding objects to the environment</p>	<p>Behaviour (indoors)</p> <p>A count of distance violations recorded electronically using a proximity device</p> <p>The addition of unidirectional arrows indicating a one-way system decreased the number of distancing violations</p> <p>$d = .40$</p>
			<p>Delivery: Walking directions unidirectional with arrows on floor decals (one lane only)</p> <p>BCTs: Potentially active None Also in comparison group 2.1 monitoring of behaviour by others without feedback 7.1 prompts and cues 12.1 restructure physical environment*</p>	<p>Delivery: Walking directions bidirectional (clockwise and anti-clockwise) with arrows on floor decals</p> <p>BCTs: Also in intervention group 2.1 monitoring of behaviour by others without feedback 7.1 prompts and cues 12.1 restructure physical environment*</p>	<p>Behaviour (indoors)</p> <p>A count of distance violations recorded electronically using a proximity device</p> <p>There were no differences between the one way and two-way systems when both were restructured</p> <p>$d = -.13$</p>
			<p>Buzzer:</p> <p>Delivery: Buzzer when within 1.5m of another person (not from your HH) – buzzing 2 seconds after contact was made</p> <p>Walking directions bidirectional (clockwise and anti-clockwise) with arrows on floor decals</p> <p>BCTs: Potentially active 2.2 Feedback on behaviour* Also in comparison group</p>	<p>Delivery: Walking directions bidirectional (clockwise and anti-clockwise) with arrows on floor decals</p> <p>BCTs: Potentially active 2.1 monitoring of behaviour by others without feedback Also in intervention 7.1 prompts and cues 12.1 restructure physical environment</p>	<p>Behaviour (indoors)</p> <p>A count of distance violations recorded electronically using a proximity device</p> <p>A delayed buzzer had no effect or had a negative effect.</p> <p>$d = -.22$</p>

Chutipthimon et al. (2020)	<p>Country: Thailand</p> <p>Data collection: Data collected 7, 8 or 9 August 2020 (control collected 6 August 2020)</p> <p>Public health measures: Since March 2020 there were government mandated measures including stay-at-home orders and the closure of schools, restaurants, and other public places, in addition to restricting the number of people allowed to socially gather</p> <p>Does not mention government physical distancing recommendation</p>	<p>N: 400</p> <p>Population: university staff, students and others</p> <p>Gender: 58.5% female</p> <p>Age: 83% 19-64</p>	<p>7.1 prompts and cues 12.1 restructure physical environment 12.5 Adding objects to the environment</p> <p>Delivery: Buzzer when within 1.5m of another person (not from your HH) – immediate buzzing after contact was made (and demonstration of how it worked)</p> <p>Walking directions unidirectional with arrows on floor decals (one lane only)</p> <p>BCTs: Potentially active 2.2 Feedback on behaviour* Also in comparison group 7.1 prompts and cues 12.1 restructure physical environment 12.5 Adding objects to the environment</p> <p>Setting: university canteen</p>	<p>Delivery: Walking directions unidirectional with arrows on floor decals (one lane only)</p> <p>Delivery: Walking directions unidirectional with arrows on floor decals (one lane only)</p> <p>Potentially active 2.1 monitoring of behaviour by others without feedback Also in intervention 7.1 prompts and cues 12.1 restructure physical environment</p> <p>Setting: university canteen</p>	<p>Behaviour (indoors)</p> <p>A count of distance violations recorded electronically using a proximity device</p> <p>Buzzers were effective in reducing distancing violations when the feedback from them was immediate and when visitors received a demonstration of the buzzer.</p> <p>$d = .42$</p>
	<p>Phase of pandemic: 3,345 – 3351 cases 58 deaths</p>	<p>Setting: online</p> <p>Delivery: No message control</p> <p>BCTs: None</p>	<p>Setting: university canteen</p> <p>Delivery: Floor decal sticker – an aggressive Covid-19 with glowing eyes and “stop Covid-19” with cut out circle for feet</p> <p>BCTs: Potentially active 5.2 Salience of consequences*†</p>	<p>Setting: university canteen</p> <p>Delivery: Floor decal sticker –footprint stickers at 2m distance</p> <p>BCTs: Also in intervention 7.1 prompts/cues* 8.3 habit formation</p>	<p>Behaviour (indoors)</p> <p>CCTV recordings used to note success and failure to distance at each of 5 markings (1-2 were side by side at the counter; 3-5 were queued adjacent)</p> <p>No difference in distancing at any marking between intervention and control</p> <p>Fewer failings in both groups at markings further away from counter</p> <p>Marking point 1: $d = -.41$ Marking point 2: $d = .11$ Marking point 3: $d = .04$ Marking point 4: $d = -.08$ Marking point 5: $d = .85$</p> <p>Mean = .10</p>

			<p>Also in comparison group 7.1 prompts/cues* 8.3 habit formation</p>		<p>Fewer failings in both groups at markings further away from counter</p> <p>Marking point 1: $d = .29$ Marking point 2: $d = -.08$ Marking point 3: $d = -.01$ Marking point 4: $d = .52$ Marking point 5: $d = .40$</p>
			<p>Setting: university canteen</p> <p>Delivery: Floor decal sticker – text “Please maintain a distance from other customers”, “Physical distancing and Win COVID-19”, “Please maintain a distance from other customers” and “Please queue here”</p> <p>BCTs: Potentially active None</p> <p>Also in comparison group 7.1 prompts/cues* 8.3 habit formation</p>	<p>Setting: university canteen</p> <p>Delivery: Floor decal sticker –footprint stickers at 2m distance</p> <p>BCTs: Also in intervention 7.1 prompts/cues 8.3 habit formation</p>	<p>Mean = .22</p> <p>Behaviour (indoors)</p> <p>CCTV recordings used to note success and failure to distance at each of 5 markings (1-2 were side by side at the counter; 3-5 were queued adjacent)</p> <p>Difference in marking point 1 (at the counter) between intervention and control but no differences at any other marking</p> <p>Fewer failings in both groups at markings further away from counter</p> <p>Marking point 1: $d = .52$ Marking point 2: $d = -.21$ Marking point 3: $d = -.25$ Marking point 4: $d = -.48$ Marking point 5: $d = -.11$</p> <p>Mean = -11</p>
Heoben et al. (2021)	<p>Country: Netherlands</p> <p>Data collection: pre outbreak data Jan 2020 – Feb 2020</p> <p>pre instruction data 29 Feb, 5, 7, 12 March</p> <p>post instruction data 19, 21 March</p> <p>post fine data 26, 28 March, 2, 4, 9, 11,16,18, 23,25, 30 April, 2 May</p>	<p>N: unknown</p> <p>Population: General population</p> <p>Gender: not reported</p> <p>Age: not reported</p>	<p>Setting: public spaces</p> <p>Delivery: Government recommendation to keep 1.5m apart</p> <p>BCTs: Potentially active 9.1 credible source*†</p>	<p>Setting: public spaces</p> <p>Delivery: Pre-outbreak measures</p> <p>BCTs: None</p>	<p>Behaviour (outdoors)</p> <p>CCTV recordings used to note failure of 1.5m distancing or when in groups of >3 people (not from your HH). Cell phone data was also collected to measure change in time spent at non-residential places</p> <p>Decline in failures to distance from 12 March (no explicit distancing rule) and continues to decline after 1.5m recommendation (after 15 March) with lowest number of 19 March (before explicit rules and announcement of fine).</p>

Public health measures:
 9 March & 12 March directives (e.g., avoiding hand shaking, working from home)
 15 March 1.5m recommended

23 March lockdown, explicit rules re 1.5m, restriction to meeting <3 people not from HH and fines for not adhering to 1.5m rule and/or group size

Phase of pandemic:

Pre-outbreak
 0 cases
 0 deaths

Pre-Instructions
 7 - 614 cases
 0 – 5 deaths

Post instructions
 2,460 – 3,631 cases
 76 – 136 deaths

Post fine
 7,431 – 40,236 cases
 546 – 4,987 deaths

Setting: public spaces

Delivery:
 Government recommendation to keep 1.5m apart
 Fines for not complying with 1.5m distancing

BCTs:
Potentially active
 10.11 future punishment*†
In comparison group
 9.1 Credible source

Setting: public spaces

Delivery:
 Government recommendation to keep 1.5m apart
 Pre-fines

BCTs:
In intervention
 9.1 credible source

12 – 19 March there is a decline in number of people on street from CCTV data (compared to Jan - Feb 2020). Number of people on street positively correlated with number of violations.

Up to 12 March number of people in non-residential places was same as pre-COVID. 12 – 19 March there is sharp decline in time spent at non-residential locations

Not possible to calculate *d* as did not count non violations

Behaviour (outdoors)

CCTV recordings used to note failure of 1.5m distancing or when in groups of >3 people (not from your HH). Cell phone data was also collected to measure change in time spent at non-residential places

After explicit rule and fines for physical distancing there is a steady increase in violations (especially on weekends) from early April to early May. Increase in violations related to increase in number of new cases.

Number of people on street positively correlated with number of violations. Time spent at non-residential locations relatively low until 4 April when started to increase. Correlation between time spent at non-residential locations and distancing violations remains even after people on street controlled for.

Not possible to calculate *d* as did not count non violations

Intentions (indoors)

4 item scale (likelihood of avoiding crowded areas in supermarket; keeping myself physically distant from others while shopping; maintaining a safe distance from people in supermarket; keep

Khoa et al (2021)

Country: USA

Study 2
 N: 104

Setting: online

Setting: online

RCT

Data collection: Data collected during Covid and before submission date of 11 Aug 2020

Population: General population

Delivery: Gain framed (“promotion”) message

Delivery:
 Image of two figures standing apart with “please maintain physical distance”

Gender: 71.2% female

Image of two figures standing apart and text “maintaining physical distance protects yourself from being infected with

BCTs:
In intervention

Public health measures:

<p>Does not mention government physical distancing recommendation</p> <p>Phase of pandemic: unknown</p>	<p>Age: 42.18</p>	<p>the coronavirus and secures your personal life”</p> <p>BCTs: Potentially active 5.1 info about health consequences* †</p> <p>In comparison 6.1 demonstration of behaviour 7.1 Prompts/cues</p>	<p>6.1 demonstration of behaviour 7.1 Prompts/cues</p>	<p>myself apart from engaging in touching of others whilst shopping)</p> <p>Not reported but assume no significant differences between control and gain framed (“promotion”)</p> <p>Cannot calculate <i>d</i></p>
		<p>Setting: online</p> <p>Delivery: Loss framed (“prevention” message</p> <p>Image of two figures standing apart (with arrow) and text “failing to maintain physical distance risks yourself of being infected with the coronavirus and endangers your personal life”</p>	<p>Setting: online</p> <p>Delivery: Image of two figures standing apart (with arrow) with “please maintain physical distance”</p> <p>BCTs: In intervention 6.1 demonstration of behaviour 7.1 Prompts/cues</p>	<p>Intentions (indoors)</p> <p>4 item scale (likelihood of avoiding crowded areas in supermarket; keeping myself physically distant from others while shopping; maintaining a safe distance from people in supermarket; keep myself apart from engaging in touching of others whilst shopping).</p> <p>Greater intentions to distance between loss framed (“prevention”) and control</p> <p>Cannot calculate <i>d</i></p>
		<p>BCTs: Potentially active 5.1 info about health consequences* † In comparison group 6.1 demonstration of behaviour 7.1 Prompts/cues</p>		
		<p>Setting: online</p> <p>Delivery: Loss framed (“prevention”) message</p> <p>Image of two figures standing apart (with arrow) and text “failing to maintain physical distance risks yourself of being infected with the coronavirus and endangers your personal life”</p>	<p>Delivery: Gain framed (“promotion”) message</p> <p>Image of two figures standing apart (with arrow) and text “maintaining physical distance protects yourself from being infected with the coronavirus and secures your personal life”</p>	<p>Intentions (indoors)</p> <p>4 item scale (likelihood of avoiding crowded areas in supermarket; keeping myself physically distant from others while shopping; maintaining a safe distance from people in supermarket; keep myself apart from engaging in touching of others whilst shopping).</p> <p>Greater intentions to distance between loss framed (“prevention”) and gain framed (“promotion”). Chronic prevention focus (i.e., a tendency to avoid losses) does not moderate this effect.</p> <p>Cannot calculate <i>d</i></p>
		<p>BCTs: Potentially active None In comparison group 5.1 info about health consequences*</p>	<p>BCTs: In intervention 5.1 info about health consequences 6.1 demonstration of behaviour 7.1 Prompts/cues</p>	

6.1 demonstration of behaviour
7.1 Prompts/cues

Study 3
N: 124

Population: General population

Gender: 43.5% female

Age: 41.77

Setting: online

Delivery: Loss framed (“prevention”) message

Image of two figures standing apart (with arrow) and text “failing to maintain physical distance risks yourself of being infected with the coronavirus and endangers your personal life”

Also, anthropomorphic condition with a scary cartoon COVID between the figures

BCTs:
Potentially active
None

In comparison group
5.1 info about health consequences*
5.2 salience of health consequences*† (in anthro vs non anthro)
6.1 demonstration of behaviour
7.1 Prompts/cues

Setting: online

Delivery: Gain framed (“promotion”) message

Image of two figures standing apart (with arrow) and text “maintaining physical distance protects yourself from being infected with the coronavirus and secures your personal life”

Also, anthropomorphic condition with a scary cartoon COVID between the figures

BCTs:
Potentially active
None

In comparison group
5.1 info about health consequences*
5.2 salience of health consequences*† (in anthro vs non anthro)
6.1 demonstration of behaviour
7.1 Prompts/cues

Fear

Loss framed (“prevention”) reported higher fear than gain framed (“promotion”). Fear was shown as a mediator of the effect of the physical distancing intervention (comparing loss and gain framed) on intentions

Cannot calculate d

Self-efficacy

There was no difference loss framed (“prevention”) and gain framed (“promotion”) on self-efficacy and this was not a mediator

$d = .27$

Intentions (indoors)

4 item scale (likelihood of avoiding crowded areas in supermarket; keeping myself physically distant from others while shopping; maintaining a safe distance from people in supermarket; keep myself apart from engaging in touching of others whilst shopping).

Higher in loss framed (“prevention”) than gain framed (“promotion”) conditions

Can't calculate d

Higher in anthropomorphic than non-anthropomorphic conditions

Can't calculate d

Interaction between above showed that when:

anthropomorphic image is absent loss framed (“prevention”) have greater intentions than gain framed (“promotion”)

Lunn et al. (2020)	<p>Country: Ireland</p>	<p>N: 500</p>	<p>Setting: online</p>	<p>Setting: online Delivery: Poster</p>	<p>$d = .59$</p> <p>anthropomorphic image increased intentions in loss framed (“prevention”) compared to anthropomorphic gain framed (“promotion”)</p>
RCT	<p>Data collection: Data collected final week of March 2020</p> <p>Public health measures: Recommendations to maintain 2m distance and limit social interaction but before rules to limit mixing of different HHS</p> <p>Phase of pandemic: 1564 – 3235 cases 9 – 71 deaths</p>	<p>Population: General population</p> <p>Gender: 49% female</p> <p>Age: 33% < 40 31% 40-59 36% > 60</p>	<p>Delivery: Poster</p> <p>Individual person poster – 4 panels, each with an image of people not maintaining social distance, with text-bubbles that foretold stories of chains of infection. Showed individuals who don’t realize they have the virus, spreading it to an identifiable vulnerable person. Including counterfactuals “if they had sat further away she’d have been ok” and open-ended implications “he has asthma”</p> <p>BCTs: Potentially active 5.1 information about health* consequences 9.3 comparative imagining of future outcomes* In comparison group 7.1 Prompts/cues 9.1 Credible source</p>	<p>Featureless figurative cartoons in 4 panels depicting social distancing in 4 social situations (i.e., walking in the street, sitting at a table, when shopping, on a football field)</p> <p>BCTs: Potentially active 6.1 demonstration of behaviour* 4.1 instructions on how to perform the behaviour In intervention 7.1 Prompts/cues 9.1 Credible source</p>	<p>$d = 1.76$</p> <p>anthropomorphic image in loss framed (“prevention”) condition increased intentions compared to non-anthropomorphic loss framed (“prevention”) condition</p> <p>$d = .70$</p> <p>Evaluation – perceived effectiveness & perceived memorability (not specified but posters showed outdoors)</p> <p>Control poster was significantly seen as more effective and memorable than intervention poster (calculated by number of people who selected maximum score as data highly skewed)</p> <p>$d = -.32$ effectiveness $d = -.37$ memorability</p>
			<p>Setting: online</p> <p>Delivery: Poster</p> <p>Transmission rate poster - 4 panels, each with an image of people not maintaining social distance, with text-bubbles that foretold stories of chains of infection.</p>	<p>Setting: online</p> <p>Delivery: Poster</p> <p>Featureless figurative cartoons in 4 panels depicting social distancing in 4 social situations (i.e., walking in the street, sitting</p>	<p>Evaluation – perceived effectiveness & perceived memorability (not specified but posters showed outdoors)</p> <p>No significant differences between the control poster and the transmission rate poster (calculated by number of people</p>

<p>Showed individuals unwittingly spreading the virus to multiple others. Including counterfactuals “Had they sat further apart those people would have been ok” and open-ended implications “will now give COVID-19 to her colleagues, they’ll give it to their families”</p>	<p>at a table, when shopping, on a football field)</p>	<p>who selected maximum score as data highly skewed)</p>
<p>BCTs: Potentially active 5.1 information about health consequences* 9.3 comparative imagining of future outcomes* In comparison group 7.1 Prompts/cues 9.1 Credible source</p>	<p>BCTs: BCTs: Potentially active 6.1 demonstration of behaviour* In intervention 7.1 Prompts/cues 9.1 Credible source</p>	<p>$d = -.15$ effectiveness $d = -.23$ memorability</p>
<p>Setting: online</p>	<p>Setting: online</p>	<p>Evaluation – perceived effectiveness & perceived memorability (not specified but posters showed outdoors)</p>
<p>Delivery: Poster Transmission rate poster - 4 panels, each with an image of people not maintaining social distance, with text-bubbles that foretold stories of chains of infection. Showed individuals unwittingly spreading the virus to multiple others. Including counterfactuals “Had they sat further apart those people would have been ok” and open-ended implications “will now give COVID-19 to her colleagues, they’ll give it to their families”</p>	<p>Delivery: Poster Individual person poster – 4 panels, each with an image of people not maintaining social distance, with text-bubbles that foretold stories of chains of infection. Showed individuals who don’t realize they have the virus, spreading it to an identifiable vulnerable person. Including counterfactuals “if they had sat further away she’d have been ok” and open-ended implications “he has asthma”</p>	<p>No differences between the transmission rate poster and the individual person poster (calculated by number of people who selected maximum score as data highly skewed)</p>
<p>BCTs: Potentially active 9.3 comparative imagining of future outcomes In comparison group 7.1 Prompts/cues 9.1 Credible source</p>	<p>BCTs: Potentially active 9.3 comparative imagining of future outcomes In comparison group 7.1 Prompts/cues 9.1 Credible source</p>	<p>$d = .17$ effectiveness $d = .14$ memorability</p>

Notes: BCT = behaviour change technique (taken from Michie et al., 2013); * = proposed primary BCT; †unique test of BCT

Table 2: Behaviour change techniques and the theoretical domains, intervention functions and potential mechanisms of action

Theoretical domains framework*	Knowledge	Beliefs about consequences	Social influences	Environmental context & resources	Physical Skills	None identified	Intervention functions**	Potential MoAs***
Policy category	Regulation	Communication / Marketing	Communication / Marketing	Environmental / social planning	Service provision	Communication / Marketing Guidelines Legislation		
Intervention functions as per TDF***	Education	Education Persuasion Modelling	Restriction Environmental restructuring Modelling Enablement	Training Restriction Environmental restructuring Modelling Enablement	Training	None identified		
2.2 Feedback on behaviour	<p>Proximity Buzzer* <i>(Blanken et al, 2020)</i> Effective – buzzer increased behaviour when feedback is immediate (2 sec delay ineffective) when coupled with physical restructuring Other BCTs: 7.1; 12.1; 12.5</p>						Education Persuasion Incentivisation Coercion Training	Motivation Feedback processes
4.1 Instruction on how to perform the behaviour	<p>Poster demonstrating behaviour* <i>(Lunn et al., 2020)</i> Inconclusive Poster demonstrating behaviour was significantly seen as more effective and memorable than other posters but did not measure intentions/behaviour Other BCTs: 6.1; 7.1; 9.1</p>						Training	Knowledge Skills Beliefs about capabilities

5.1 Information about Health Consequences

Health consequences message*

(*Bos et al., 2020*)

Ineffective no difference in intentions between this and a measurement only control or moral duty message

Other BCTs: 9.1

Moral duty message (*Bos et al., 2020*)

Inconclusive message focusing on moral duty influenced intentions compared to message only control but no difference compared to health consequences message.

Other BCTs: 9.1; 13.2

Gain framed “promotion” poster † (*Khoa et al., 2021*)

Ineffective no difference between Gain framed “promotion” and control poster on intentions

Other BCTs: 6.1; 7.1

Loss framed “prevention” poster* (*Khoa et al., 2021*)

Effective – increased intention when compared to Gain framed “promotion” focused poster (2 studies) and control (1 study)

Other BCTs: 6.1; 7.1

Poster with consequences to individual people or about transmission rate*

(*Lunn et al., 2020*)

Inconclusive ind person and transmission rate not effective in increasing effectiveness and memorability (and did not measure intentions or behaviour)

Other BCTs: 7.1; 9.1; 9.3

Education
Persuasion

Knowledge
Beliefs about consequences
Intention
Attitude towards the behaviour
Perceived susceptibility / vulnerability

7.1 prompts / cues

6.1 demonstration of behaviour

5.2 Saliency of Consequences

Floor decal markers with scary COVID*†
(Chutiphimon et al., 2020)
Inconclusive – floor decal 2m markers with scary COVID don't increase behaviour when compared to other 2m floor decal markers
Other BCTs: 7.1; 8.3

Loss framed “prevention” poster with scary covid*†
(Khoa et al, 2021)
Effective – Loss framed “prevention” focused posters were effective in increasing intention when compared the same posters w/o the scary COVID and Gain framed “promotion” posters
Other BCTs: 5.1; 6.1; 7.1

Gain framed “promotion” poster (Khoa et al, 2021)
Ineffective no difference between Gain framed “promotion” and control poster on intentions
Other BCTs: 5.1; 7.1

Loss framed “prevention” poster* (Khoa et al, 2021)
Effective – increased intention when compared to Gain framed “promotion” focused poster (2 studies) and control (1 study)
Other BCTs: 5.1; 7.1

Poster demonstrating behaviour* (Lunn et al., 2020)
Inconclusive
Poster demonstrating behaviour was significantly seen as more effective and memorable than other posters but did not measure intentions/behaviour
Other BCTs: 4.1; 7.1; 9.1

Note – no studies compared a condition with prompts and cues and one without any prompts and cues

Education
Environmental restructuring

Memory, attention & decision processes
Environmental context and resources
Behavioural cueing

Training
Modelling

(Persuasion)

Beliefs about capabilities
Social learning / imitation
Intention

Beliefs about consequences
Perceived susceptibility / vulnerability
Intention

12.1 restructuring physical environment	10.1.1 future punishment	9.3 comparative imagining of future outcomes	9.1 credible source	8.3 Habit formation	Note: no studies compared conditions with habit formation strategies and one without habit formation strategies	Environmental restructuring Enablement	(Coercion)	(Enablement)	Persuasion	(Training)	Environmental context and resources Behavioural cueing	
			<p>Poster with consequences to individual people or about transmission rate* (Lunn et al., 2020) Inconclusive ind person and transmission rate not effective in increasing effectiveness and memorability (and did not measure intentions or behaviour) Other BCTs:5.1; 7.1; 9.1</p>						<p>Health consequences / moral duty message (Bos et al., 2020) Inconclusive as no difference between a control and a health consequences message from a credible source but difference with a moral duty message from a credible source Other BCTs: 5.1; 13.2</p>		Behavioural cueing	
									<p>Government Guidelines*† (Hoeben et al., 2021) Inconclusive – behaviour occurred before explicit government recommendations. May require other measures in place (e.g., stay at home orders) to facilitate change Other BCTs: N/A</p>		Attitude towards the behaviour General attitudes / beliefs	
									<p>Government Fines*† (Hoeben et al., 2021) Ineffective – no evidence that fines influenced behaviour Other BCTs: 9.1</p>		Beliefs about consequences	
											<p>Directional walking system * (Blanken et al, 2020) Effective one-way walking system increased behaviour but no difference with bi-directional system Other BCs: 2.2; 7.1</p>	

12.5 Adding objects to environment

13.2 framing / reframing

Proximity Buzzer*
(Blanken et al., 2020)
Effective – buzzer increased behaviour when feedback is immediate (2 sec delay ineffective) when coupled with physical restructuring
Other BCTs: 2.2; 7.1; 12.1

Moral duty message* †
(Bos et al., 2020)
Inconclusive message focusing on moral duty influenced intentions compared to message only control, but no difference compared to health consequences message.
Other BCTs: 5.1; 9.1

Environmental restructuring
Enablement

(Enablement)
(Persuasion)

Environmental context and resources
Behavioural cueing

Attitude towards the behaviour
Intention

*The Theoretical Domains were determined from an expert consensus exercise (Cane et al., 2015)

**The Intervention Functions were determined from a review of interventions (p. 151-155, Michie et al., 2014). Less frequently used in brackets

*** The Intervention Functions were determined from an expert consensus exercise (p.113-115, Michie et al., 2014)

**** The MoAs were determined from an expert consensus exercise (Connell et al., 2018; Johnston et al., 2020)

Table 3: Quality of studies

Study	Screening		Randomised Controlled Trials						Non Randomised Trials					Quantitative Descriptive Study					Total (%)
	Clear RQ	Data addresses RQ	Rand appropriately performed	Comparable groups at baseline	Complete outcome data (Δ 80%)	Outcome assessor blinded	Ps adhere to assigned Int	Ps representative	Appropriate measurement	Complete outcome data (Δ 80%)	Confounders accounted for	Int delivered as intended	Relevant sampling strategy	Representative sample	Appropriate measurement	Low non response bias	Appropriate analysis		
Bos et al. (2020)	Yes	Yes	x	Yes	No	?	No	Yes										2 (40%)	
Blanken et al. (2020)	Yes	Yes						No	Yes	?	Yes	Yes						3 (60%)	
Chutiprimon et al. (2020)	Yes	Yes						Yes	Yes	Yes	No	Yes						4 (80%)	
Hoeben et al. (2021)	Yes	Yes											Yes	No	Yes	No	Yes	3 (60%)	
Khoa et al. (2021) – study 2	Yes	Yes		?	?	Yes	No	Yes										2 (40%)	
Khoa et al. (2021) – study 3	Yes	Yes		?	?	Yes	No	Yes										2 (40%)	
Lunn et al. (2020)	Yes	Yes						Yes	Yes	?	No	?						2 (40%)	

Notes: RQ = research question; Int = intervention; Ps = participants; ? = can't tell; Low quality was categorised as 0-1; moderate quality was categorised as 2-3; and high quality was categorised as 4-5.

Supplementary materials

Example of search

PubMed

("physical distancing"[MeSH Terms] AND (("methods"[MeSH Terms] OR "methods"[All Fields] OR "intervention"[All Fields]) OR ("clinical trials as topic"[MeSH Terms] OR ("clinical"[All Fields] AND "trials"[All Fields] AND "topic"[All Fields]) OR "clinical trials as topic"[All Fields] OR "trial"[All Fields]) OR experiment[All Fields])) AND ("pandemics"[MeSH Terms] OR "epidemics"[MeSH Terms] OR "influenza, human"[MeSH Terms])

Table S1 Dates of data collection

	Jan 20	Feb 20	Mar 20	Apr 20	May 20	Jun 20	Jul 20	Aug 20
Bos et al. 2020			■					
Blanken et al. 2020								
Chutipimon et al. 2020								■
Hoeben et al. 2021	■	■	■	■	■			
Lunn et al. 2020			■					
Khoa et al. 2021								