

# Determinants of behaviour and their efficacy as targets of behavioural change interventions

Dolores Albarracín<sup>1,2,3,4,5</sup>✉, Bita Fayaz-Farkhad<sup>2</sup> & Javier A. Granados Samayoa<sup>1,3</sup>

## Abstract

Unprecedented social, environmental, political and economic challenges – such as pandemics and epidemics, environmental degradation and community violence – require taking stock of how to promote behaviours that benefit individuals and society at large. In this Review, we synthesize multidisciplinary meta-analyses of the individual and social-structural determinants of behaviour (for example, beliefs and norms, respectively) and the efficacy of behavioural change interventions that target them. We find that, across domains, interventions designed to change individual determinants can be ordered by increasing impact as those targeting knowledge, general skills, general attitudes, beliefs, emotions, behavioural skills, behavioural attitudes and habits. Interventions designed to change social-structural determinants can be ordered by increasing impact as legal and administrative sanctions; programmes that increase institutional trustworthiness; interventions to change injunctive norms; monitors and reminders; descriptive norm interventions; material incentives; social support provision; and policies that increase access to a particular behaviour. We find similar patterns for health and environmental behavioural change specifically. Thus, policymakers should focus on interventions that enable individuals to circumvent obstacles to enacting desirable behaviours rather than targeting salient but ineffective determinants of behaviour such as knowledge and beliefs.

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<sup>1</sup>Department of Psychology, University of Pennsylvania, Philadelphia, PA, USA. <sup>2</sup>Annenberg School of Communication, University of Pennsylvania, Philadelphia, PA, USA. <sup>3</sup>Annenberg Public Policy Center, University of Pennsylvania, Philadelphia, PA, USA. <sup>4</sup>Department of Community and Family Health, School of Nursing, University of Pennsylvania, Philadelphia, PA, USA. <sup>5</sup>Department of Health Care Management, Wharton School of Business, University of Pennsylvania, Philadelphia, PA, USA. ✉e-mail: [dalba@upenn.edu](mailto:dalba@upenn.edu)

## Introduction

During the past 5 years, humanity has been confronted with extraordinary social, environmental, political and economic challenges, including pandemics and epidemics, threats to natural habitats and climate, and community, state and police violence. The science of behaviour change can identify efficacious interventions to change behaviours that might be central to solving these crises. Thus, it is important to understand the degree to which correcting misinformation, modifying cultural beliefs, or changing norms or legal sanctions will, for example, increase vaccination or decrease energy usage.

Previous work has provided taxonomies of the tools available to change behaviour<sup>1–3</sup>. For example, a review and expert judgements were used to classify behavioural change interventions, determine whether they were based on behavioural change principles and, then, organize them into displays that enable practitioners to visualize possible tools at their disposal<sup>4,5</sup>. However, despite its descriptive value, this taxonomy is not informative about the relative intervention efficacy of different approaches. An intervention based on ‘behavioural change principles’ does not guarantee success, therefore leaving the question of efficacy unaddressed.

Other relevant work has produced estimates of specific strategies across behaviours, but these estimates are typically obtained by comparison with a control group rather than other strategies<sup>6–9</sup>. For example, past reviews of the efficacy of implementation intentions (forming if–then plans to execute a behaviour) or normative appeals<sup>10–13</sup> are not informative about whether implementation intentions are more or less efficacious than behavioural skills training, or whether interventions that make group norms more apparent are more or less efficacious than programmes that aim to increase the trustworthiness of institutions.

Existing reviews that do compare the efficacy of interventions across different targets have been circumscribed to specific domains, such as health<sup>14</sup>, climate change mitigation<sup>15</sup> and human immunodeficiency virus (HIV) prevention and care<sup>16–18</sup>. This traditional focus on single behavioural domains might arise because research funding is often allocated by problem (as illustrated by the disease-specific organization of the National Institutes of Health (NIH), the main health research funding agency in the USA) or because researchers are often trained in siloes and assume that each issue is unique.

From a theoretical standpoint, understanding a broad spectrum of behavioural domains is critical to a generalizable behavioural change model. From a practical standpoint, new behavioural change challenges will continue to surface. For example, before the COVID-19 pandemic, no research had examined how to promote widespread masking, social distancing or adherence to lockdown measures. Thus, reviewing targets of behavioural change across domains is essential for well-informed public health decisions in unprecedented situations.

In this Review, we synthesize disparate bodies of research to facilitate decisions about what behavioural change targets to choose when designing an intervention. First, we define a parsimonious set of individual and social-structural determinants of behaviour based on existing theories, supplemented by an extensive review of the literature and author verification that the final groupings were meaningful, parsimonious and relatively homogeneous. Next, we summarize the meta-analytic evidence for correlations between each naturally occurring determinant (for example, knowledge) and behaviour, as well as meta-analytic effect sizes for experimental and quasi-experimental tests of the efficacy of behavioural interventions that target that determinant (for example, interventions that provide information to increase knowledge). We conclude by organizing intervention approaches into

an empirical model of behavioural change based on their efficacy to provide a picture of general principles that can inform intervention decisions for new or understudied behaviours.

Our Review includes all identified meta-analyses of behaviour prediction or intervention efficacy across domains (Supplementary Note 1) based on clearly classifiable determinants, targets of change and behavioural outcomes. However, although interventions designed to change a particular target are assumed to change that specific target<sup>16</sup>, they might exert an array of effects. For example, an intervention that communicates that neighbours use less energy might influence both descriptive norms and positive attitudes towards conserving energy<sup>19</sup>. Verifying all possible mechanisms of effects is outside the scope of this Review.

We concentrated on what targets might be most effective, which is the first critical question when designing a programme to change behaviour. For example, deciding whether to instil pro-vaccination norms, combat conspiracy theories about vaccination or add vaccination sites is essential to the public health management of a pandemic. However, implementing interventions once a target of change is selected brings up a different set of questions that are outside the scope of this Review. Although we briefly describe what interventions often do, readers should review the primary research literature to determine what the most successful interventions within a given target look like. After all, reviewing intervention manuals is critical to a faithful programme implementation<sup>20–22</sup>.

## Behavioural determinants

Individual factors are at the centre of behavioural prediction and change models such as the reasoned action approach<sup>20–25</sup>, the information–motivation–behavioural-skills model<sup>16,20,23,26–29</sup> and social cognitive theory<sup>25,30–32</sup>. These models collectively suggest that knowledge (a collection of facts about an object of behaviour, typically held with certainty even though they might be factually incorrect<sup>32</sup>), beliefs (probability judgements about an object in connection with an attribute or an outcome<sup>32</sup>), general and behavioural attitudes (evaluations of objects or behaviours, respectively, along a positive–negative dimension<sup>33</sup>), emotions (visceral feelings associated with an object or behaviour<sup>33</sup>), general and specific skills (cognitive skills involved in self-control<sup>30</sup> or domain-specific cognitive or motor skills, respectively<sup>30</sup>) and habits (repeated, automated behaviours that continue even in the absence of rewards<sup>34</sup>) are important determinants of behaviour and/or potential targets for behaviour change.

For example, according to the reasoned action approach, beliefs that performing a behaviour will lead to various outcomes and the evaluations of those outcomes influence attitudes and subsequent intentions to execute a behaviour<sup>20</sup>. According to the information–motivation–behavioural-skills model, information entails knowledge about the behaviour in question, motivation comprises attitudes, norms and intentions, and behavioural skills encompass routines that facilitate a behaviour and associated feelings of self-efficacy or perceived behavioural control<sup>24,27,30,35</sup>. Emotions, habits, general attitudes and general skills are part of the integrative model of behavioural prediction and change<sup>21</sup> and have been shown to be important for self-regulation<sup>29</sup>. They are also incorporated as external variables within the reasoned action approach<sup>29</sup>.

One problem with existing models of behavioural prediction and change is a relative neglect of social and structural factors<sup>2,36</sup>. For example, although the reasoned action approach posits that social norms influence intentions, intentions are still an individual factor.

Similarly, even though social cognitive theory emphasizes the impact of others as models of behaviour<sup>30</sup>, the theory also includes self-efficacy and personal agency, which are individual factors.

Nevertheless, several theories suggest important social-structural determinants of behaviour that could be targets of behavioural change. For example, there are theoretical distinctions between injunctive norms (perceptions of the degree to which others support a person's behaviour<sup>20,37</sup>) and descriptive norms (subjective estimates of the frequency of a behaviour in a particular population<sup>38–41</sup>), and these two norms do not always correlate with each other ( $r = 0.1–0.4$ )<sup>42–44</sup>. There are also theoretical distinctions between regulatory and distributed policies<sup>45</sup>, which led to our decision to separate formal legal and administrative sanctions (legal and administrative instruments to ban or punish a behaviour) from institutional trustworthiness (justice or fairness within an organization or government entity, which increases trust and reduces vigilance<sup>46–48</sup>), which can often be achieved in informal ways such as demonstrating benevolence (ref. 49 and A. H. Jung et al., unpublished data). Moreover, material incentives (provision of financial or non-financial rewards) can affect the motivation to perform a behaviour and are theoretically important drivers of behaviour<sup>50,51</sup>.

The literature also suggests other social-structural factors that might be particularly relevant for determining behaviour and driving behaviour change. For example, a large literature suggests that social support influences human behaviour<sup>52</sup>, and increasing the feasibility of behaviour such as through access and defaults<sup>2</sup> (material or logistic resources to facilitate the performance of a behaviour) or monitors and reminders<sup>53,54</sup> (physical or digital instruments that track behavioural performance and alert users of the need to execute a behaviour) is an important aspect of intervention design<sup>53,54</sup>.

In sum, the classification of individual and social-structural determinants of behaviour we use in subsequent sections based on the above considerations is more comprehensive and theory-based than classifications of nudges<sup>1</sup> and considerably more parsimonious and theory-driven than classifications of behavioural change techniques<sup>55</sup>.

## Individual determinants and interventions

Individual determinants of behaviour include knowledge, beliefs, attitudes, emotions, skills and habits (Table 1). In this section, we synthesize results from meta-analyses of correlational studies that measure the determinant along with the behaviour in question (Supplementary Table 1) and meta-analyses of randomized controlled trials, quasi-experimental studies and laboratory research of behavioural change interventions based on these determinants (Supplementary Table 2). Determinants are discussed in order from least to most effective when targeted by interventions.

In comparing effect sizes across studies, readers should keep in mind their meaning (Table 2) and interpretational limitations. For example, in a correlational study, an odds ratio of 2 between knowledge and behaviour implies that for each increasing unit in the measure of knowledge, the probability of behaviour doubles. However, correlational studies do not inform the degree to which changing knowledge will produce a change in behaviour. Similarly, in an intervention context, an odds ratio of 2 implies that the behaviour is twice as likely following exposure to a knowledge-based intervention relative to the control group. However, in both cases, the ultimate meaning of the effect size depends on the baseline probability of executing the behaviour. An odds ratio of 2 implies much greater savings in energy if 30% of the control group saves energy than if only 3% of the control does so.

## Knowledge

Knowledge links an object or behaviour to an attribute or event with absolute certainty and is often formally imparted through educational efforts. For example, knowledge that a COVID-19 vaccine exists or that human activity contributes to climate change is accepted by many individuals and endorsed by governments. The associations between knowledge and behaviour are often studied under the umbrella of 'literacy', which involves a body of facts and mental models in a particular domain. For example, financial literacy (a person's financial knowledge<sup>56,57</sup>) correlates with desirable financial behaviours at  $r = 0.29$  (ref. 57). However, the association between financial literacy and behaviour is extremely small ( $r = 0.09$ ) when the behaviour is measured after the measure of literacy was obtained instead of before (ref. 57).

There is also extensive research on the relation between literacy and behaviour in the health and environment domains, but effects are small (Supplementary Table 1). For example, there is a negligible association between oral health literacy and visiting the dentist ( $OR = 1.25$ )<sup>58</sup> and between HIV knowledge and actual condom use ( $r = 0.06$ )<sup>44</sup>, and small associations between recycling literacy and recycling ( $r = 0.20$ )<sup>59</sup> and between climate change knowledge and climate change-adaptation behaviours such as supporting environmentally friendly policies or relocating in response to climate change ( $r = 0.14$ )<sup>60</sup>. One potential explanation for the lack of a sizable correlation between knowledge and behaviour overall (Fig. 1a) is that the knowledge is only tenuously related to the behaviours being studied. For example, knowledge related to alcohol and its effects might be inconsequential if drinking is related to normative or other beliefs<sup>20</sup>.

Interventions that target knowledge involve education (for example, systematic instruction to individuals or groups) and other didactic approaches intended to reduce a knowledge deficit. Meta-analyses of behavioural effects suggest that these interventions produce negligible effects (Fig. 1b). For example, educational approaches have a negligible effect on climate change mitigation ( $d = 0.09$ )<sup>15</sup>. Similarly, a meta-analysis of vaccination interventions showed that neither providing information in general nor attempting to correct misinformation increases vaccination uptake ( $OR = 1.04$  and  $OR = 0.94$ , respectively) (S. Liu et al., unpublished).

Importantly, some of the effect sizes derived from the correlational evidence are larger than the largest effects obtained from intervention studies. Thus, using correlational evidence to make inferences about interventions might lead to the selection of ineffective programmes. Even more critical is the fact that the efficacy of knowledge as a target of change is negligible. From this standpoint, building a campaign or programmes to increase knowledge is likely to leave policymakers and constituents disappointed.

## General skills

Broad behavioural and cognitive skills (for example, the ability to control attention during tasks or inhibit temptations when behaviours require high levels of self-control) are small predictors of behaviour (Fig. 1a). For example, prosocial skills are not significantly correlated with obtaining employment during adolescence (overall  $OR = 1.03$ )<sup>61</sup> and executive functioning skills (which comprise inhibitory control and cognitive flexibility) correlate only at  $r = -0.14$  with disinhibited eating<sup>62</sup>.

Many behavioural change programmes have emphasized the need to train general skills that might help individuals to control undesirable behaviours<sup>62</sup>. Other interventions are based on mindfulness principles, with the rationale that mindfulness can reduce aggression and other

**Table 1 | Individual determinants of behaviour and associated measures and interventions**

Determinant	Definition	Example measures	Example interventions
Knowledge	Collection of facts about an object or behaviour, which can include information about the properties and consequences of a particular object or event, such as a virus or pollution; knowledge links an object or behaviour to an attribute or event with absolute certainty	Measure of literacy: “Contact with a dirty toilet is a common cause of venereal disease or sexually transmitted disease” (participant responds ‘true’ or ‘false’) <sup>213</sup>	Health education Didactic instruction about climate change in schools
General skills	Cognitive or overt routines that enable individuals to carry out various specific behaviours; they involve broad capacities such as controlling attention during tasks and being able to inhibit temptations when behaviours require high levels of self-control	Self-report measures of self-control, which include statements about a person’s ability to make a plan or avoid temptations <sup>214</sup>	Behavioural change programmes emphasizing the need to train general skills that might help individuals to control undesirable behaviours <sup>137</sup>
General attitudes	Evaluations of objects, persons and events; for example, prejudice is a negative judgement of a group as the attitude object, and an attitude towards cars is a positive or negative evaluation of cars as the attitude object; this type of attitude is often termed ‘attitude towards the target’ <sup>23,215</sup>	Likert-scale measure of attitudes towards environmental protections: “Humans are severely abusing the environment” <sup>216</sup> Implicit attitude test concerning alcohol <sup>217</sup>	Mass-media health-promotion campaigns about a behaviour <sup>79</sup> Interventions aimed at weakening associations by instilling goals and threat <sup>80</sup>
Beliefs	Subjective assignments of probability that an object or behaviour has a given attribute or outcome <sup>32,218</sup>	Self-report measure of conspiracy beliefs: “To what extent do you think the virus is part of a biological warfare program?” <sup>219</sup>	Messages that explicitly introduce expectations about a behaviour Growth mindset interventions in academic settings
Emotions	Visceral feelings (for example, happiness or fear) associated with a particular object, person or event; experiencing fear of climate change or disgust about a particular group of individuals are examples of emotion	Likert-scale measure of emotions towards COVID-19: “I feel fearful about COVID-19” <sup>220</sup>	Emotional appeals that sensitize audiences to risks and include discussion of the threat posed by a problem or the audience’s susceptibility to it
Behavioural skills	Routines that enable people to execute a target behaviour, often reflected in higher levels of perceived control or efficacy concerning the behaviour <sup>30,134,218</sup>	Self-report measure of behavioural control and confidence to perform or abstain from a behaviour: “If I wanted to, it would be easy for me to exercise for at least twenty minutes, three times a week for the next fortnight” <sup>221</sup>	Practising and receiving feedback on the behaviour and performing homework related to the behaviour <sup>222,223</sup> Asking individuals to formulate implementation intentions <sup>222,223</sup>
Behavioural attitudes	Evaluations of a behaviour as good or bad; for example, whereas an attitude towards cars is a general attitude, an attitude towards driving a car for transportation is a behavioural attitude; this type of attitude is often referred to as ‘attitude towards the behaviour’ <sup>23</sup>	Semantic differential measures of attitudes linking recycling to adjectives such as good or bad: “Recycling household waste for me is something ...” (participant selects from five-point response scale anchored by adjectives ‘good’ and ‘bad’) <sup>224</sup>	Mode of questioning designed to uncover and reduce attitudinal ambivalence towards a particular behaviour <sup>144,145</sup>
Habits	Behavioural routines that have acquired features of automaticity <sup>225</sup> , meaning that they occur efficiently, without awareness, or continue even without intention and after they are no longer adaptive <sup>151,226</sup>	Measure of handwashing habit: “Washing my hands would require effort not to do” <sup>227</sup>	Training to stop a behaviour when faced with temptations <sup>157,158</sup> Introducing environmental regularity to promote habit formation <sup>150</sup> Distracting oneself from behavioural cues <sup>159</sup>

impulsive behaviours. A meta-analysis of mindfulness interventions for children and adolescents found a small effect on reducing negative behaviours ( $d = 0.21$ )<sup>63</sup>. Overall, the effect of general skills interventions is negligible (Fig. 1b).

## General attitudes

Psychologists have long considered whether general attitudes towards objects (for example, attitudes towards recycling) predict behaviour (for example, actual recycling). A narrative review from the late 1970s found that of 54 studies of the relation between general attitudes and behaviour, 25 showed null results and those that showed significant results rarely exceeded an effect size of  $r = 0.40$  (ref. 64). More recent meta-analyses suggest that the relation between general attitudes and behaviour is quite small ( $d = 0.22$  (ref. 65) and  $r = 0.14$  (ref. 66)), whereas others suggest that the relation is much stronger ( $r = 0.39$ )<sup>67</sup>.

An interesting wrinkle in the study of general attitudes is the proposal that researchers measure implicit attitudes in addition to the traditional measures of attitudes used in the meta-analyses described above. Implicit attitude measures are designed to capture relatively automatic evaluative responses through spontaneous participants’ judgements or timed responses to a task<sup>68–71</sup>. In the implicit association test, for example, implicit attitudes are measured by comparing the time required to pair an object with the concept ‘good’ with the time required to pair an object with the concept ‘bad’<sup>72</sup>. However, these measures have produced negligible to medium associations with behaviour as well. For example, in the area of substance use, there is a medium association between implicit attitudes towards legal and illegal psychoactive substances and substance use ( $r = 0.27$ )<sup>73</sup>.

Whereas the overall association between general attitudes and specific behaviours is medium in size (Fig. 1a), the effect size



corresponding to intervention efficacy is negligible (Fig. 1b). For example, a meta-analysis of mass-media health-promotion campaigns revealed a negligible effect on behaviour change ( $r = 0.05$ )<sup>74</sup>. Moreover, a meta-analysis found that although various techniques led to shifts in implicit attitudes, these trainings had little effect on behaviour. For example, interventions that aimed to weaken associations between an object and a particular evaluation had a negligible influence on behaviour ( $g = -0.10$ )<sup>75</sup>.

Clearly, people report general attitudes that correlate with their behaviours even though attempts at changing these attitudes have a much lower efficacy potential than the correlational evidence suggests. It might be that people rationalize their behaviour when they report general attitudes (consistent with research on cognitive dissonance and self-perception<sup>76–78</sup>), even though those attitudes did not have a causal role in producing behaviour. Regardless, general attitudes are relatively inconsequential targets of change.

## Beliefs

Similar to knowledge, specific beliefs about an object or behaviour have positive relations to behavioural performance (Fig. 1a). However, there is a range of effect sizes across domains, with larger effect sizes for environmental versus health behaviours. For example, a meta-analysis of the determinants of recycling found medium correlations between expectations of positive feelings if one recycles or negative feelings if one does not recycle correlate with actual recycling ( $r = 0.26$ )<sup>59</sup> (note that expectations of feelings are beliefs in the probability of experiencing particular emotions and not emotions themselves). By contrast, the correlations between condom use and the perceived attractiveness of condoms ( $r = 0.14$ ) and the belief that condom use protects people from HIV infection ( $r = 0.10$ ) are small, and the correlation between condom use and the belief that purchasing condoms is embarrassing is negligible ( $r = -0.05$ )<sup>44</sup>.

Specific beliefs have also been investigated in the context of conspiracy theories. Intuitively, endorsing COVID-19 conspiracy theories might seem quite consequential for the likelihood of engaging in activities such as wearing a mask or social distancing. However, the effects are not unlike those of knowledge and other beliefs (Supplementary Table 1). In fact, a meta-analysis of crossed-lagged correlations from 17 samples estimated the impact of conspiracy beliefs on risky COVID-19-related behaviour to be  $\beta = 0.09$  (ref. 79) with a reciprocal effect from behaviour to beliefs of similar magnitude. Thus, even these dramatic beliefs exert negligible effects on behaviour.

Other commonly studied beliefs are cultural. These beliefs entail judgements related to religiosity, spirituality, fashion, food consumption, interpersonal relationships and the relative standing of different social groups, including interactions among group members and with other groups<sup>80</sup>. Cultural beliefs can act as barriers to action when the recommended behaviour is incongruent with cultural beliefs. For instance, cultural beliefs can constitute roadblocks to participation in community-based health insurance when a culture views preparation for illness as a magnet for illness itself<sup>81</sup>. Similarly, cultural beliefs about food consumption, which designate which foods are healthy or unhealthy, can act as a barrier to the management of diabetes when they conflict with recommendations provided by health-care professionals<sup>82</sup>.

Quantitative reviews have estimated the relation between different kinds of cultural beliefs and behaviour. For instance, hostile sexism (a collection of negative beliefs about the role of women in society and their relation to men) has a medium correlation with male-to-female

violence ( $z = 0.26$ ), whereas the relation between benevolent sexism (a collection of beliefs that women have positive qualities but need to be protected) and male-to-female violence is negligible ( $z = 0.05$ )<sup>83</sup>. As for religious beliefs, greater religiosity correlates with lower engagement in criminal behaviour ( $r = -0.12$ )<sup>84</sup> and a combination of religiosity and spirituality correlates with less physical aggression ( $r = -0.12$ ) and less sexual aggression and domestic violence ( $r = -0.05$ ), albeit weakly<sup>85</sup>. More generally, greater religious involvement is associated with less engagement in destructive behaviour ( $z = -0.17$ ) and more engagement in constructive behaviour ( $z = 0.20$ )<sup>86</sup>. However, some Christian groups are philosophically opposed to what they consider unnecessary medical intervention, resulting in disparities in vaccination coverage across religions<sup>87</sup>.

Cultural beliefs have important implications for many behaviours<sup>88–91</sup>. For example, in the USA, Hispanic people have the lowest rates of smoking among all racial and ethnic groups<sup>92</sup>, probably owing to less acculturation (the degree to which people from minority groups retain their native cultural language and values relative to those of the new, dominant culture<sup>93</sup>) than other groups<sup>94</sup>. Furthermore, the prevalence of risky behaviours, including smoking, obesity and unhealthy eating and drinking habits, is higher among second-generation Americans born in the USA than first-generation immigrants to the USA ( $r = 0.01–0.28$ ). It seems that individuals living in the USA but born in other countries (for example, Mexico and China) have closer ties to their traditional cultures, which promote healthier lifestyle choices<sup>95</sup>. This ‘immigrant paradox’ characterizes the situation of immigrants who practised healthy dietary behaviours in their home countries but abandon them as they acculturate to their new country of residence<sup>90</sup>.

When existing interventions fail to meet the needs of racial and ethnic minority groups, culturally tailored programmes can be developed by modifying the content, language, mode of delivery or other intervention components in existing interventions or new programmes that consider cultural context can be developed based on the group’s concerns<sup>96</sup>. However, the impact of culturally tailored interventions on health behaviours is seemingly negligible ( $g = 0.1–0.20$ )<sup>97</sup>. For example, interventions designed to address hypermasculinity (machismo) beliefs among Hispanic adolescents are successful at reducing the likelihood of engaging in HIV risk behaviour by 32% relative to participants in the control groups<sup>98</sup>, whereas a cultural adaptation of a substance use intervention for Latinx adolescents had a negligible effect ( $g = 0.06$ )<sup>99</sup>. In fact, five out of seven of the effects of such cultural adaptations were negligible (Supplementary Table 2).

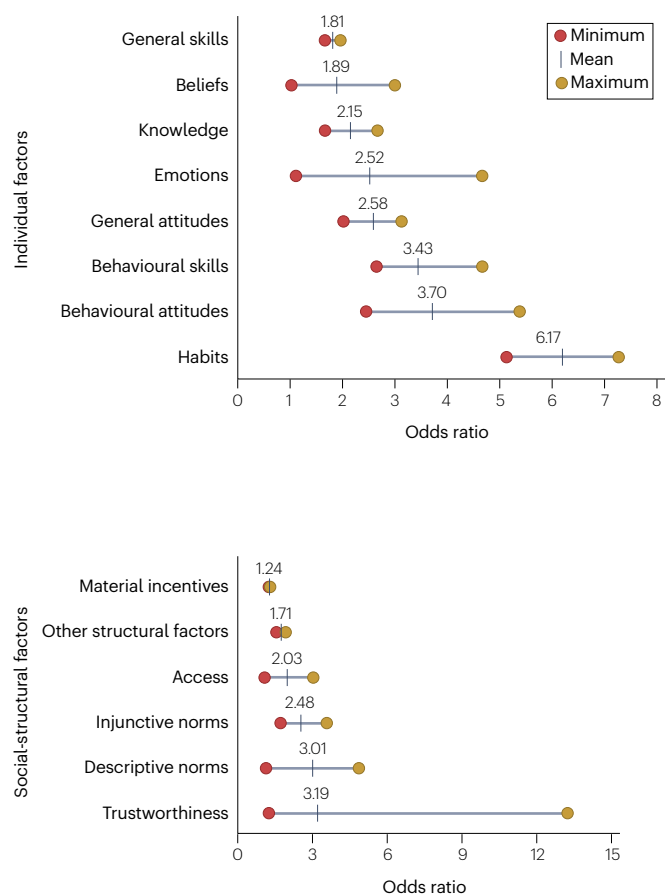
As with knowledge and general attitudes, the effect sizes for beliefs derived from the correlational evidence (Fig. 1a) are larger than the largest effects obtained from intervention studies (Fig. 1b). For example, confidence in one’s ability to grow in a particular domain (growth mindset) is associated with improved performance in academic settings<sup>100–102</sup>. Accordingly, interventions have been developed to

**Table 2 | Interpretation of effect sizes**

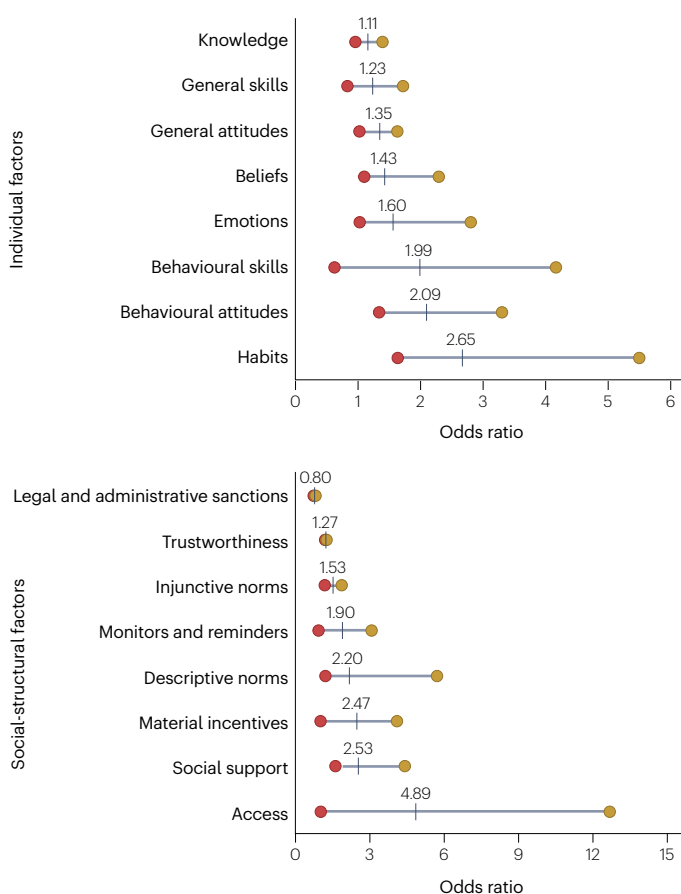
	<i>d</i> or <i>g</i>	<i>r</i> or <i>z</i>	Odds ratio or risk ratio
Negligible	<0.2	<0.1	<1.44
Small	0.2–0.49	0.1–0.23	1.44–2.47
Medium	0.5–0.79	0.24–0.36	2.48–4.26
Large	≥0.8	≥0.37	≥4.27

*d* or *g*, standardized mean difference; *r*, Pearson correlation coefficient; *z*, standardized *r* coefficient.

## a Meta-analyses of determinants



## b Meta-analyses of interventions



**Fig. 1 | Effect size range in meta-analyses of behaviour change. a, b,** Range (minimum, red; maximum, yellow) and mean (line) of effect sizes (odds ratios) for meta-analyses of individual (Supplementary Table 1) and social-structural (Supplementary Table 3) determinants of change (panel a) and for meta-analyses of intervention studies that targeted individual (Supplementary Table 2) and

social-structural (Supplementary Table 4) determinants (panel b). Only meta-analyses that excluded extreme publication bias are included (Supplementary Note 1). Mean odds ratio values are presented above the mean line. Odds ratios <1.44 are negligible, those ≥1.44 but <2.48 are small, those ≥2.48 but <4.27 are medium and those ≥4.27 are considered large.

change mindsets in the hope of also improving academic performance. However, a meta-analysis of these interventions found a negligible effect on behaviour both in experiments that successfully altered mindset ( $d = 0.04$ ) and when considering all experiments ( $d = 0.05$ )<sup>8</sup>.

## Emotions

Experiencing fear of climate change or disgust about a particular group of individuals present examples of emotion. Emotional appeals are commonly used to sensitize audiences to the risks of an object or event and include discussion of the threat posed by a problem or the audience's susceptibility to it<sup>103</sup>. Emotions feature prominently in behavioural change models (for example, the health belief model<sup>104–106</sup>). However, the correlations between negative emotions and/or risk and behaviour tend to be small or negligible. For example, there is a small correlation ( $r = 0.12$ ) between anxiety about COVID-19 and COVID-19 protective behaviours (although the correlation with fear is medium in size,  $r = 0.24$ )<sup>107</sup>. Similarly, the association between perceived climate change risk and past adaptation behaviour is only  $r = 0.10$  (ref. 60), and the association between perceived HIV risk and condom use is only

$r = 0.06$  (ref. 44). The results tend to be similar for other forms of perceived threat (Supplementary Table 1). For example, in the domain of condom use, the associations between worry or concern and perceived HIV severity are  $r = 0.09$  and  $r = 0.02$ , respectively<sup>44</sup>.

Social emotions (emotions that serve primarily social functions and involve reactions to how the self is perceived by others, such as pride, gratitude, guilt, anger and envy<sup>108,109</sup>) have garnered attention from behavioural scientists studying interpersonal behaviours. For example, people's tendency to experience anger while driving has a small association with speeding behaviour ( $r = 0.12$ )<sup>110</sup> and is more strongly associated with a composite of high-risk driving behaviours ( $r = 0.39$ )<sup>111</sup>. As other examples, envy has a weak negative relation with positive workplace behaviours such as help-seeking ( $r = -0.21$  to  $0.05$ ; median  $r = -0.03$ ) and a stronger relation with negative workplace behaviours such as incivility ( $r = 0.27$ – $0.33$ ; median  $r = 0.29$ )<sup>112</sup>. Likewise, guilt is associated with greater engagement in pro-environmental behaviours ( $r = 0.30$ )<sup>113</sup>; gratitude is associated with prosocial behaviour ( $r = 0.26$ )<sup>114</sup>; the affective experience of interpersonal attraction is correlated with a behavioural composite of amount of talking, head

nodding and sitting distance ( $r = 0.20$ )<sup>115</sup>; and emotional prejudice is more strongly associated with discriminatory behaviour ( $r_{\text{median}} = 0.35$ ) than stereotypes and other beliefs<sup>116</sup>. Finally, even though social emotions are not consistently associated with purchasing behaviour ( $r_{\text{gratitude}} = 0.50$ ;  $r_{\text{pride}} = 0.07$ ;  $r_{\text{guilt}} = -0.01$ ;  $r_{\text{anger}} = -0.19$ ), they have medium to large correlations with sharing behaviour ( $r_{\text{gratitude}} = 0.74$ ;  $r_{\text{pride}} = 0.32$ ;  $r_{\text{guilt}} = 0.54$ ;  $r_{\text{anger}} = -0.38$ )<sup>117</sup>. However, these strong associations with sharing behaviour might partly be a function of the lower cost of this behaviour (operationalized as complaining and word of mouth in the source meta-analysis) compared with purchasing behaviour.

Generally, inducing emotions influences behaviour ( $g = 0.31$ )<sup>118</sup>. Although negative emotions have been found to have no overall effect on food consumption ( $g = 0.02$ ), positive emotions increase food intake ( $g = 0.24$ )<sup>119</sup>. Likewise, communicating to induce fear tends to have small effects (Supplementary Table 2). For example, communicating the level of genetic cardiometabolic risk to patients has no effect on dietary changes or weight loss<sup>120</sup>. Moreover, despite occasional claims of backfire effects<sup>121</sup>, a comprehensive meta-analysis of fear-appeal experiments found that the effects of risk information and fear were positive but negligible in size ( $d = 0.20$  (ref. 122) and  $d = 0.14$  (ref. 103), respectively). Furthermore, inductions of both anticipatory emotions (for example, fear and worry;  $d = 0.21$ ) and anticipated emotions (for example, regret, guilt and shame;  $d = 0.30$ ) produce positive but small changes in the enactment of behaviour<sup>123</sup>. All in all, the effects of emotions are small.

Many interventions have targeted social emotions to bring about behavioural change<sup>124</sup>. In particular, gratitude interventions are popular in the positive psychology literature<sup>125</sup>. However, the overall effects of gratitude interventions are small. For example, meta-analyses have found negligible effects of gratitude interventions on exercise ( $d = 0.10$ ) and prosocial behaviour ( $d = 0$  and  $d = 0.12$ )<sup>114</sup>, and a stronger but still small effect on behaviours that express gratitude (for example, writing a thank-you note;  $d = 0.40$ )<sup>125</sup>.

As with the other individual determinants reviewed thus far, the effect sizes for emotions are stronger in correlational than intervention studies. Although the available evidence suggests medium correlations between emotions and behaviour (Fig. 1a), concluding that they might be a desirable avenue for intervention could lead to underwhelming results as the efficacy of emotion-based interventions is small (Fig. 1b).

## Behavioural skills

Specific behavioural skills show a medium-sized correlation with actual behaviour (Fig. 1a). For example, mothers who have the skills to discuss birth control methods with their daughters are 5.69 times more likely to have their daughters vaccinated against human papilloma virus (HPV) than mothers who lack such communication skills<sup>126</sup>. In addition, specific behavioural skills are often reflected in people's sense of the controllability of a particular behaviour (perceived behavioural control)<sup>22,127</sup>. For example, according to meta-analyses, perceived behavioural control has a strong association with actual recycling ( $r = 0.39$ )<sup>59</sup>, and confidence that one can refuse alcohol (refusal self-efficacy) has medium associations with the frequency of drinking ( $r = -0.35$ ), the quantity of alcohol consumed ( $r = -0.29$ ) and binge drinking ( $r = -0.32$ )<sup>128</sup>.

Behavioural skills interventions involve receiving arguments about the execution of a set of skills, as well as observing a role model execute a behaviour, practising and receiving feedback on the behaviour, and performing homework related to that behaviour<sup>27,129</sup>. For example, verbal arguments might be used to encourage individuals

to secure resources for and overcome obstacles to wearing a condom during sex<sup>130</sup> and more practical behavioural skill training interventions involve role-playing the application of condoms<sup>16</sup>. Teenagers might practise refusing invitations to smoke cigarettes or drink alcohol<sup>131–133</sup>, and adults might be taught to avoid drinking before or during sex or to monitor their emotional states to avoid risky sexual situations<sup>27,134</sup>.

Meta-analyses of these types of interventions have shown that training behavioural skills provides benefits for behavioural change. For example, communication skills training effectively increases both safer-sex discussions with partners ( $d = 0.35$ ) and condom use ( $d = 0.39$ )<sup>135</sup>. Organizational training across various such as interpersonal communication also produces sizable improvements in work behaviour ( $d = 0.62$ ), particularly for programmed instruction ( $d = 0.94$ ), which is given in small, specific steps that require a correct response before the learner moves to the next step<sup>136</sup>. Although the overall effect size for intervention efficacy is small (Fig. 1b), behavioural skills are among the more promising targets to achieve behavioural change and have more sizable effects than general skills ( $d = 0.62$  (ref. 136) versus  $d = 0.30$  (ref. 137)).

## Behavioural attitudes

Studies of attitudinal determinants involve analyses of associations with behavioural attitudes as well as indirect measures of behavioural attitudes (beliefs about behavioural outcomes weighted by evaluations of those outcomes<sup>20,138</sup>). A general meta-analysis of newly formed attitudes estimated that the link between attitudes towards behaviours and actual behaviour is large ( $r = 0.58$ )<sup>139</sup>. These findings are supported by meta-analyses in other domains. For instance, there is a medium correlation between attitudes towards sun-protection behaviour and actual sun-protection behaviour ( $r = 0.31$ )<sup>140</sup>, and large correlations between attitudes towards car use and actual car use ( $r = 0.41$ )<sup>141</sup>, attitudes towards consuming organic vegetables and organic vegetable consumption ( $r = 0.44$ )<sup>142</sup>, and attitudes towards condom use and actual condom use ( $r = 0.38$ )<sup>138</sup>. Similarly, indirect attitude measures show a medium correlation with condom use ( $r = 0.31$ )<sup>138</sup>. Thus, behavioural attitudes are generally better predictors of behaviour than general attitudes, knowledge and specific beliefs (Fig. 1a).

Interventions targeting behavioural attitudes include media messages or in-person discussions of the benefits of changing a behaviour<sup>130,143</sup>, as well as motivational interviewing designed to reduce attitudinal ambivalence towards a particular behaviour<sup>144,145</sup>. However, interventions to change attitudes towards behaviours are generally comprehensive and include other strategies such as targeting norms and perceived behavioural control<sup>20,127</sup>. Consequently, many intervention studies provide little information on the specific impact of targeting behavioural attitudes. Laboratory experiments designed to impact behavioural attitudes as a way of influencing behaviour have found large effects on behaviours ( $d = 1.10$  and  $d = 0.79$ )<sup>146</sup>, but the effects of actual interventions are typically small (Supplementary Table 2). Overall, the effects of behavioural attitude interventions are small (Fig. 1b).

As with the other individual determinants, the differences in effect sizes between correlational and intervention studies are considerable. Importantly, the correlational studies that find the strongest associations measured behaviour in the laboratory<sup>139</sup> and involve behaviours that exist only in those contexts (for example, voting in support of a fictitious policy as part of an experiment<sup>139,147</sup>). Consequently, these experiments are poor representatives of the complex decisions people make when attitudes coexist with other factors.



## Habits

Past behaviour is an important precursor of future behaviour. For example, past condom use has a medium correlation with current condom use ( $r = 0.36$ )<sup>44</sup>, and past recycling behaviour has large correlations with future recycling ( $r = 0.41$ )<sup>59</sup> and seeing oneself as a person who recycles ( $r = 0.48$ )<sup>59</sup>.

Habits have been equated with past behaviour in many analyses<sup>148</sup>. However, contemporary theories define habits as repeated behaviours that exhibit automaticity, occur without awareness and are difficult to stop even when they no longer provide benefits to the individual<sup>149–154</sup>. A meta-analysis of associations between health-provider habits (for example, handwashing) measured with habit scales that tap into automaticity showed a medium association with the execution of those behaviours ( $r = 0.33$ )<sup>155</sup>, and another meta-analysis found a large association between car habits and car use ( $r = 0.50$ )<sup>156</sup>. In sum, habits have large associations with behaviours (Fig. 1a).

Habit-promoting interventions involve<sup>157,158</sup> training to stop behaviour in the face of temptations<sup>157,158</sup>, introducing environmental regularity to promote habit formation<sup>150</sup> and distracting people from behavioural cues<sup>159</sup>. For example, laboratory cognitive training to inhibit approach to food cues, promote distraction, reappraise food cravings and use other cognitive control techniques has a small effect on food intake ( $g = 0.27$ ), with reappraisal ( $g = 0.45$ ), attentional bias modification ( $g = 0.44$ ) and distraction ( $g = -0.31$ ) having the strongest effects<sup>159</sup>. Similarly, a meta-analysis found that stop signal training ( $d = -0.39$ ) and attentional bias modification ( $d = -0.51$ ) showed small and medium effects on eating behaviour, respectively<sup>160</sup>.

Habit reversal training has also been used to reduce tics<sup>158</sup>. In this treatment, patients are trained to identify occurrences of the tic and the events that trigger it and implement a competing, incompatible response. For example, if stress or hunger increases tics, activation of antagonist muscles when a tic is expected can eliminate the tic<sup>158</sup> ( $d = 0.94$ )<sup>157</sup>. This treatment changes motor associations with external stimuli and therefore reduces behaviours that are executed despite undesirable consequences.

Interventions to curb habits are impressive because they are fighting against chronic, automated tendencies that are difficult to eliminate. As with many of the individual factors we considered, the effects obtained from correlational studies are markedly stronger than the corresponding effects from intervention studies. Nevertheless, interventions to train habits are clearly promising and, among all individual targets, demonstrate the strongest impact on behavioural change (Fig. 1b). However, they face the challenge of needing to elicit behaviour before that behaviour can become automated.

## Social-structural determinants and interventions

Social-structural determinants of behaviour include legal and administrative sanctions, trustworthiness, injunctive norms, monitors and reminders, descriptive norms, material incentives, social support and access (Table 3). Although these determinants reflect social and environmental conditions, the measures of determinants often rely on self-report. For example, descriptive norms tap into how much others perform a behaviour, but measures in correlational studies reflect a respondent's perception of what others do. In this section, we synthesize results from meta-analyses of correlational studies that measure the determinant along with the behaviour in question (Supplementary Table 3) and meta-analyses of randomized controlled trials, quasi-experimental studies and laboratory research of behavioural change interventions based on these determinants (Supplementary Table 4).

Determinants are discussed in order from least to most effective when targeted by interventions. As noted above, readers should keep in mind their meaning (Table 2) and interpretational limitations when comparing effect sizes across studies.

## Legal and administrative sanctions

We identified no meta-analyses of correlations between behaviour and legal and administrative sanctions. In terms of interventions, policies that attempt to ban negative behaviour and link it to sanctions (for example, restricting one's ability to work or travel if one chooses not to get vaccinated)<sup>161</sup> have been criticized for their potential for psychological reactance (a negative emotional response caused by threats to or actual losses of freedom)<sup>162,163</sup>. Specifically, people generally believe that they possess a certain level of freedom and wish to have control over their actions. When they encounter events restricting their perceived freedom, they might become motivated to restore it by acting against the threatening events. Accordingly, although deterrence theory has remained a cornerstone of criminal justice policy, deterrence-based initiatives have only small to medium effects on behaviour ( $r = 0.22–0.33$ )<sup>164</sup> and mandates can sometimes work, as shown by the success of COVID-19 vaccination mandates in many places<sup>165–167</sup>. Collectively, however, legal and administrative sanctions have a negligible effect on behaviour (Fig. 1b).

## Trustworthiness

Interpersonal trust is a combination of attitudes, affective reactions and beliefs about others (for example, health-care providers or politicians) that reduces interpersonal vigilance and increases vulnerability<sup>46–48</sup>. For instance, the trustworthiness of an individual delivering a message has been found to influence its persuasiveness<sup>168–174</sup>. Trust has been frequently studied in the context of cooperation games, where trust in one's game partner strongly predicts altruistic behaviour ( $r = 0.58$ )<sup>175</sup>. Trust has also been examined in organizational research, where intra-team trust is associated with better team performance ( $r = 0.30$ )<sup>176</sup>, and trust in leaders is associated with better task performance ( $r = 0.26$ ) and better organizational citizenship behaviour ( $r = 0.30$ )<sup>177</sup>.

Behavioural scientists are also interested in institutional forms of trust, such as trust in scientists and government institutions. One meta-analysis found that climate-friendly behaviours correlated with trust in governmental institutions ( $r = 0.17$ ), trust in environmental groups ( $r = 0.38$ ), trust in industry ( $r = 0.14$ ) and trust in scientists ( $r = 0.33$ )<sup>178</sup>. However, these associations tend to be stronger for public behaviours (for example, support of public environmental policies) than for private behaviours (for example, obtaining health insurance)<sup>178</sup>.

Notably, specific factors can change the strength and direction of these associations. For example, there were small correlations between trust in government institutions and compliance with COVID-19 behavioural guidelines ( $r = 0.11$ ) and COVID-19 vaccination ( $r = 0.10$ )<sup>179</sup>. However, trust in former President Donald Trump correlated negatively with all COVID-19 prevention behaviours<sup>179</sup>. Overall, there is a medium-sized association between all forms of trustworthiness and behaviour (Fig. 1a).

Interventions to increase institutional trustworthiness focus on increasing the perceived fairness and goodwill of authorities or organizations, in addition to programmes to increase distributed and procedural justice. Interventions aimed at improving the perceived trustworthiness of health-care authorities lead to negligible increases in behavioural outcomes ( $g = 0.13$ )<sup>180</sup>. Interventions to increase distributed justice at work have produced negligible effects on work performance ( $OR = 1.20$ )<sup>181</sup>, whereas interventions to increase procedural



**Table 3 | Social-structural determinants of behaviour and associated measures and interventions**

Determinant	Definition	Sample measures	Sample interventions
Legal and administrative sanctions	Legal and administrative instruments to prescribe, ban or sanction a behaviour	State and county records of laws coded through a policy review <sup>228</sup>	Banning smoking in public establishments <sup>229</sup> Mandating vaccination <sup>230</sup> Mandating sick pay <sup>231</sup> Taxing pollution <sup>232</sup>
Trustworthiness	Justice or fairness within an organization or government entity, which leads constituents to follow recommendations <sup>49</sup>	Self-report measure of procedural justice: “How fair were the procedures used to handle the problem?” <sup>233</sup>	Providing channels for Latinx voters to voice their concerns Community-oriented policing that fosters non-enforcement interactions <sup>234</sup>
Injunctive norms	Perceptions of the degree to which others support a person’s behaviour <sup>20,37</sup>	Self-report measure of injunctive norms: “People who are important to me think I should use condoms” <sup>21</sup>	Messages that communicate that others approve of condom use <sup>235</sup> Posting signs stating that taking the stairs is a good way to get some exercise <sup>236</sup>
Monitors and reminders	Physical or digital instrument to track behavioural performance and remind users of the need to execute a behaviour	Self-reported use of pill boxes, diaries and planners <sup>237</sup>	Clinical reminder system for promoting preventive care <sup>238</sup> Digital watches and phone apps that promote physical activity
Descriptive norms	Frequency of a behaviour in a particular population <sup>38–41</sup>	Self-reported perceptions of what others do: “Most residents would vaccinate their child against COVID-19” <sup>228</sup>	Comparative feedback such as a chart tracking one’s energy consumption in relation to one’s neighbours <sup>239</sup> Using role models to promote a target behaviour <sup>30,31</sup> Posting signs stating that most people used the stairs <sup>236</sup>
Material incentives	Providing financial or non-financial rewards in exchange for a behaviour	Introduction of state lottery for vaccinated residents as a reward for vaccinations <sup>240</sup>	Paying people US \$24 to receive the COVID-19 vaccine <sup>241</sup>
Social support	Informational, instrumental or financial help to facilitate a particular behaviour <sup>201</sup>	Self-reported lists of individuals who can perform instrumental, informational and emotional support functions <sup>242</sup>	Leveraging family or ad hoc groups to assist individuals to meet their physical activity goals Groups of Latina mothers led by ‘promotoras’ who support and accompany each other during health-promoting activities <sup>243</sup>
Access	Material or logistic resources to facilitate the performance of a behaviour	Census demographics and self-report of health insurance <sup>244</sup> Self-reported health insurance <sup>245</sup>	Reducing co-payments for medication <sup>246</sup> Providing health insurance <sup>247</sup> Providing basic income <sup>248</sup>

justice have small positive effects on work behaviour (OR = 1.49)<sup>182</sup>. Overall, however, interventions that aim to increase institutional trustworthiness have a negligible effect (Fig. 1b).

## Injunctive norms

Several health behaviour theories (for example, the theories of reasoned action and planned behaviour<sup>20,23</sup>, as well as the theory of normative focus<sup>37,183</sup>) converge on the hypothesis that social norms influence behaviour. Injunctive norms (perceptions of the degree to which others support one’s behaviour<sup>20,37</sup>) have small associations with behaviours such as blood donation ( $r = 0.17$ )<sup>42</sup>, recycling ( $r = 0.21$ )<sup>59</sup> and adolescent sexual behaviour ( $r = 0.22$ )<sup>13</sup>. Overall, however, the correlation between injunctive norms and behaviour is medium in size (Fig. 1a).

Over the past five decades, social normative interventions (for example, messages that communicate that others approve of specific behaviours) have been used to change environmental behaviours<sup>124</sup>, child-rearing practices<sup>12</sup>, health<sup>184</sup> and other risky behaviours by making people feel that others approve of the course of action recommended in the intervention. A synthesis of these interventions across numerous domains revealed a small effect on behaviour ( $d = 0.34$ )<sup>185</sup>. The impact of injunctive norm interventions has also been synthesized in the domain of environmental behaviour, revealing a negligible effect ( $d = 0.10$ )<sup>186</sup>. Notably, these interventions can have effects because people are unaware of the true injunctive norms<sup>187</sup>. For example, if most students drink heavily because they assume their peers approve of drinking, reporting

disapproving injunctive norms can curb drinking<sup>188</sup>. Overall, however, interventions that target injunctive norms have small effects (Fig. 1b).

## Monitors and reminders

We identified no meta-analyses of correlations between behaviour and monitors and reminders. In terms of interventions, monitors and reminder interventions can, potentially, delegate monitoring and reminder functions to the environment and consequently decrease self-control failures<sup>189</sup>. Manual reminders (for example, tracking sheets and paper planners) can promote various health screenings, including for breast, cervical and colorectal cancer (OR = 1.63, OR = 1.10 and OR = 1.85, respectively)<sup>190</sup>. However, they fail to influence preventive care more generally (OR = 0.99)<sup>190</sup> and have negligible effects on vaccination (OR = 0.95) (S. Liu et al., unpublished). Often, the use of both manual and computer-generated reminders is most effective (colorectal cancer screening OR = 2.57; all preventative care OR = 2.23)<sup>190</sup>. Overall monitors and reminders have a small effect (Fig. 1b). Thus, they might be a useful intervention strategy, particularly in combination with interventions for other targets.

## Descriptive norms

Descriptive norms contribute to the social processes that shape a wide range of behaviours. Although descriptive norms do not correlate with blood donation behaviour ( $r = 0.03$ )<sup>42</sup>, they do correlate with recycling ( $r = 0.33$ )<sup>59</sup>, adolescent sexual behaviour ( $r = 0.40$ )<sup>13</sup>, consumer

behaviour ( $r = 0.31$ )<sup>9</sup> and smoking initiation ( $OR = 1.88$ – $2.53$ )<sup>43</sup>. Overall, there is a medium-sized association between descriptive norms and behaviour (Fig. 1a).

Most normative interventions try to persuade recipients that others already behave in the recommended ways. In fact, simply communicating descriptive social norms changes behaviour in various settings, especially when the desired behaviour is highly prevalent<sup>191</sup>. For example, college students tend to overestimate the amount of alcohol consumed by their peers<sup>187</sup> and normative interventions that revise this misperception reduce drinking<sup>182</sup>. Indeed, meta-analyses of approaches to modify descriptive norms have shown small effects for alcohol use ( $d = 0.29$ )<sup>192</sup> and condom use ( $d = 0.36$ )<sup>11</sup>.

Other normative interventions include providing comparative feedback such as a chart tracking one's energy consumption in relation to one's neighbours<sup>186</sup>. Although people often dislike comparative feedback<sup>193,194</sup>, exercise apps that provide comparative feedback are highly effective ( $d = 0.96$ )<sup>195</sup>.

Having role models to look up to and learn from<sup>30</sup> is a particularly influential normative intervention ( $d = 0.51$ )<sup>186</sup>. This finding is consistent with evidence that interventions delivered by facilitators who resemble recipients demographically are more successful at increasing condom use than interventions delivered by demographically dissimilar facilitators<sup>173</sup>. Overall, interventions that aim to change descriptive norms have small effects on behaviour (Fig. 1b).

## Material incentives

Correlational evidence about the effects of material incentives suggests that offering incentives for biochemically validated samples produces medium increases in smoking cessation (risk ratio =  $2.58$ )<sup>196</sup>. Other effects, however, are negligible. For example, receiving state subsidies is minimally correlated with environmentally friendly application of pesticides ( $g = 0.12$ )<sup>197</sup>.

Many policies designed to promote human behaviour adopt behaviourist principles<sup>198</sup> by pairing positive behaviour with incentives (for example, providing financial incentives for choosing to get vaccinated). However, the overall efficacy of incentives is small (Fig. 1b). For example, financial incentives were offered by many countries to encourage COVID-19 vaccination but, according to a meta-analysis, the effects were negligible ( $OR = 1.44$ ) (S. Liu et al., unpublished). Financial incentives have also been used to decrease energy consumption, where the effects are small ( $d = 0.36$ )<sup>199</sup>, and to curb substance use, where the effects are medium ( $d = 0.70$ )<sup>200</sup>.

## Social support

Social support (the provision of informational, instrumental or financial help to facilitate a particular behaviour<sup>201</sup>) has been examined in relation to stress and health, as well as particularly difficult behaviours that benefit from external advice and assistance, such as weight loss, medication adherence and resource conservation. Social support differs from norms in that, as studied in relation to behaviour, the support concerns a particular behavioural goal. Whereas social norms might concern others' approval for maintaining a healthy diet, social support implies that others are willing to provide advice or other forms of help around a particular dietary goal.

There are variable associations between social support and behaviour. For example, adherence to medical treatments is 1.74 times higher among patients with cohesive families and 1.53 times lower among patients with high-conflict families<sup>152</sup>. Moreover, exercise is facilitated by support from family and important others ( $d = 0.36$  and  $d = 0.44$ ) as

well as exercise-class leaders and classmates ( $d = 0.31$  and  $d = 0.32$ )<sup>153</sup>. In addition, there are large associations between emotional, material and informational support and the quality of childcare behaviours executed by mothers ( $r = 0.31$ ,  $r = 0.27$  and  $r = 0.31$ , respectively)<sup>154</sup>.

The effect of social support interventions is medium (Fig. 1b). These interventions often take the form of support groups that facilitate a behaviour such as the dietary or physical activity modifications required to lose weight. Such social support interventions are associated with small positive effects on adherence to antiretroviral medication ( $OR = 1.66$ )<sup>202</sup> and a reduction in suicide ( $OR = 0.48$ )<sup>203</sup>. Social support interventions based on public commitments to a behaviour<sup>204</sup> (which can increase a person's motivation to execute a behaviour but also social support for it) are associated with small ( $d = 0.26$ )<sup>15</sup> to medium ( $g = 0.58$ )<sup>186</sup> increases in conservation behaviour.

## Access

According to social cognitive theory<sup>24</sup>, environmental attributes can constrain behaviour and thereby act as critical determinants of behaviour. For example, increases in the price of pesticides decrease environmentally friendly pesticide application ( $d = -0.36$ )<sup>197</sup>. Likewise, demographic variables related to a person's position within the social hierarchy have a range of associations with behaviour. For example, healthy behaviours during pregnancy correlate with income ( $r = 0.26$ )<sup>205</sup> and having a recycling bin and owning a home both correlate with recycling ( $r = 0.16$  and  $r = 0.24$ , respectively)<sup>59</sup>. Overall, the association between access and behaviour is small (Fig. 1a).

Some access interventions are designed to impact the system at large. Interventions to decrease inequality are attractive, given large disparities in behaviours that benefit individuals and society at large. Accordingly, researchers have tested structural and community interventions, such as microfinancing, which involves small loans to develop a business as a source of income. However, randomized controlled trials testing the impact of microloans showed a negligible effect on women's control over household expenses ( $d = -0.01$ )<sup>206</sup>. In the area of health, broader structural and community interventions have small effects as well (risk ratio =  $1.20$  and risk ratio =  $0.90$  for condom use and number of partners, respectively)<sup>207</sup>.

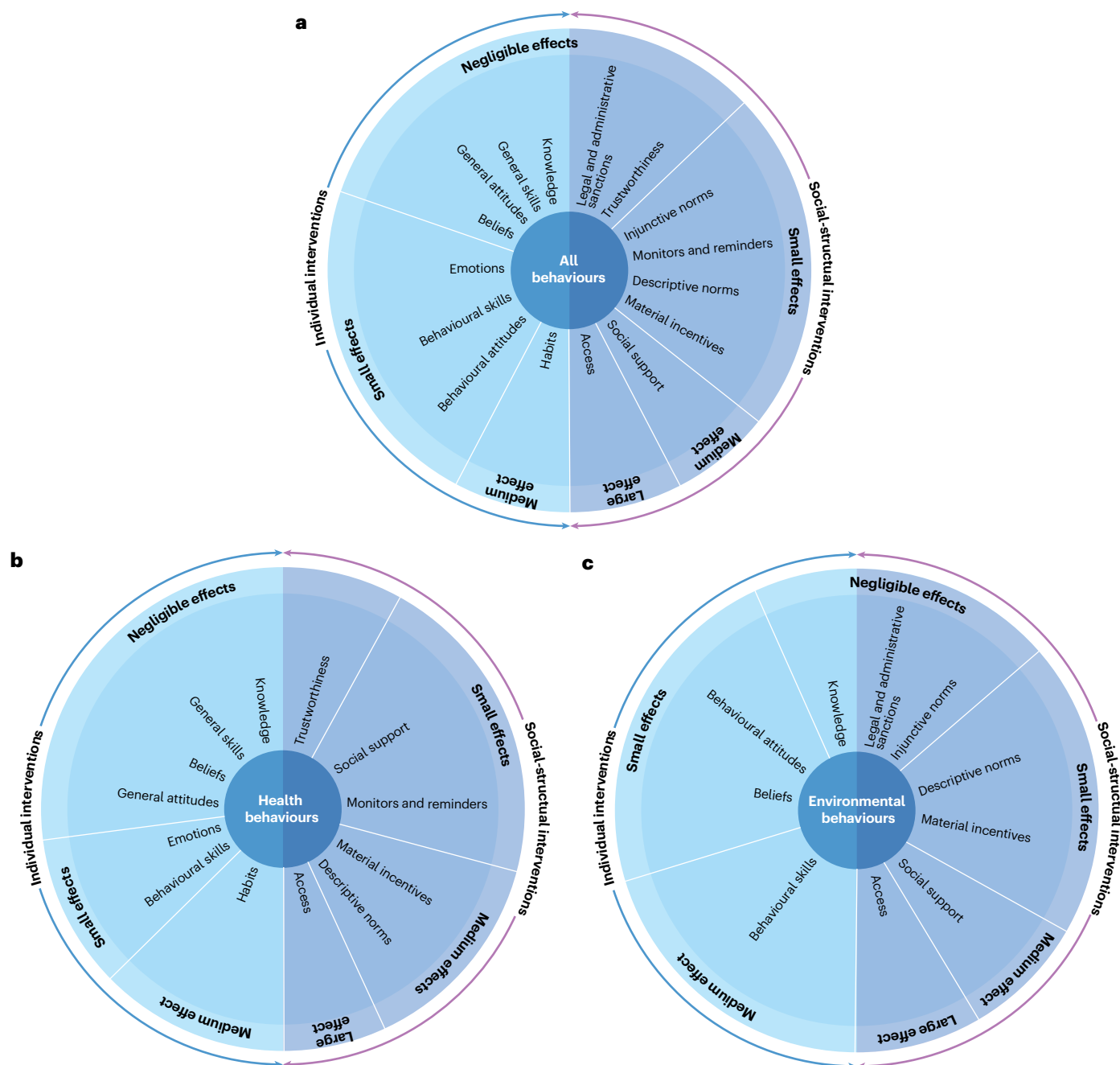
Other policy instruments increase access by changing the environment to offer more specific opportunities for behavioural change. For example, interventions that ensure access to vaccines by providing transportation or sites close to potential users double vaccination coverage (S. Liu et al., unpublished). Other policies design situations that channel behaviour, such as making the desired behaviour the default on organ-donation forms ( $d = 0.68$ )<sup>208,209</sup>. Yet others decrease access by taxing alcohol to reduce use ( $OR = 5.92$ )<sup>210</sup>. Overall interventions that aim to increase access have large effects on behaviour (Fig. 1b).

## Summary and future directions

Our Review suggests that across domains, knowledge, general skills, general attitudes, beliefs, legal and administrative sanctions, and trustworthiness have negligible effects as targets of intervention; emotions, behavioural skills, behavioural attitudes, injunctive norms, monitors and reminders, descriptive norms and material incentives have small effects; habits and social support have medium effects; and access has large effects (Fig. 2a). Of course, some behaviours, populations and contexts might be unique. Thus, no review or meta-analysis can predict the result of an intervention across all contexts. Nevertheless, our Review suggests that certain variables, although highly salient, might not change behaviour and should not be the primary focus of a

behavioural intervention. Moreover, the discrepancies in effect sizes between correlational studies and intervention studies suggest that correlational studies are often ill-suited as a basis for deciding what determinants to address in interventions.

A key aim of our Review was to offer a synthesis across all behaviours. To determine the extent to which these conclusions are generalizable, we examined determinants for health behaviour (Fig. 2b) and environmental behaviour (Fig. 2c) specifically. These domains



**Fig. 2 | Models of behavioural change intervention efficacy.** a–c, Conclusions of our synthesis of meta-analyses of behaviour change interventions for all behaviours (panel a), health behaviours (panel b) and environmental behaviours (panel c). In all panels, individual targets of change are presented on the left and social-structural targets of change are presented on the right. Vertically,

targets of change are organized from least to most effective based on the average effect sizes for each behavioural target (Fig. 1b; Supplementary Figs. 1 and 2), and grouped based on whether effects are negligible, small, medium or large (Table 1). Only meta-analyses that excluded extreme publication bias are included (Supplementary Note 1).

were chosen because they have been assessed in most meta-analyses (Supplementary Note 2). The distribution of individual determinants for health behaviour is the same as that for all behaviours. The distribution is similar for environmental behaviour, except that the data are less complete. The efficacy data for social-structural factors related to health and environmental behaviours are sparser but still revealing. In both cases, interventions that target descriptive norms, material incentives, social support and access are promising, whereas interventions that emphasize institutional trustworthiness in the health domain and legal and administrative sanctions or injunctive norms in the environmental domain might be insufficient to move populations to change.

Thus, the next pandemic and current climate change crisis will require not knowledge but, rather, active approaches that enable individuals to circumvent obstacles and gain support, and that ensure access to resources in ways that promote positive behaviour in all groups. For example, the US campaign for COVID-19 vaccination targeted vaccine confidence (general attitudes). However, our Review suggests that it would have been more appropriate to increase access to vaccination, in addition to training behavioural skills, strengthening norms, leveraging social support and using material incentives. Our Review also suggests that behavioural skills training should be effective to induce behaviours to curb climate change. However, in that case, actual beliefs also have a small effect, suggesting that the dominant intervention emphasis of increasing perceptions of climate change and its outcomes, albeit insufficient, is not misguided.

The next step for intervention researchers is to link these conclusions to specific intervention contents and policies. For example, randomized controlled trials should test different methods to change descriptive norms or specific implementations of interventions designed to increase access to a behaviour. Importantly, researchers and policymakers need to stop repeating programmes that are typically unsuccessful. For example, although some boilerplate information about a behaviour should routinely be introduced to an audience not familiar with a behaviour or the goal of a behaviour, launching large efforts to test the efficacy of interventions to increase institutional trust or corrections for misinformation seems futile if the motivation is behavioural change. Finally, more trials that test different intervention targets are needed so that future research reviews can draw on more data that better control for populations and contexts. Such controls are not possible when different experiments test different targets of change.

Researchers should also study naive theories about behavioural change among policymakers and their constituents. If policymakers believe that knowledge is fundamental to behavioural change, they will continue to implement well-intended but unsuccessful interventions. Likewise, if policymakers consider all targets of change as equally attractive possibilities without considering their relative efficacy, their choices are also likely to be misguided. Understanding these naive conceptualizations and how they translate into behavioural change initiatives is critical to ensuring that evidence-based findings similar to those provided here shape the practise of behavioural change.

Any literature review has limitations. First, our review did not specifically consider that different channels might be used to impart knowledge or modify beliefs or injunctive norms. For instance, individualized knowledge might be imparted to a person who visits with a dietician, delivered to schools or broadcast on mass media. In these situations, even when the beliefs exist within the minds of individuals, interventions might operate at the individual, school or community level. Similarly, policies to increase access to services might be

implemented at the level of an organization, county, state, nation or group of nations that enter international agreements. Which level or combination of levels produces the most effective interventions is an important question for future research.

Second, the choice to synthesize meta-analyses might have biased our conclusions because some areas have been meta-analysed more than others. However, meta-analysis remains the only method that allows for comparisons across research that uses different metrics<sup>211,212</sup>. A first-order meta-analysis of this large intervention literature might be an aspirational goal for the field that might be feasible with newer forms of automation. Until then, our review of meta-analyses is informative and actionable. Behavioural change is likely to remain one of the most important solutions to humanity's challenges, and we must be armed with more and better guidelines to promote it.

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## Author contributions

All authors researched data for the article and extracted effect sizes. All authors contributed substantially to discussion of the content. D.A. wrote the main sections of the article and all authors contributed to the first draft and all revisions. All authors reviewed and/or edited the manuscript before submission.

## Competing interests

The authors declare no competing interests.

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