Laidlaw Undergraduate Leadership and Research Programme 2025

A Systematic Scoping Review of Strategies to Reduce Vaccine Hesitancy: Exploring Their Impact on Public Trust and Attitudinal Change.

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Abstract

Background: Vaccine hesitancy remains a major threat to immunisation programmes, contributing to the return of vaccine-preventable diseases such as measles. While a growing body of research has examined strategies to address hesitancy, findings remain scattered, with trust often overlooked as a central outcome.

Objective: This scoping review mapped recent randomised controlled trials (RCTs) of interventions aimed at reducing vaccine hesitancy, with a particular focus on public trust and attitudinal change.

Methods: A librarian-assisted search was conducted across Scopus, Embase, MEDLINE, Web of Science, and PsycINFO (June 2025). Eligible studies were RCTs published in 2024–2025 that explicitly targeted vaccine hesitancy, trust, or confidence. Data were independently extracted by two reviewers, critically appraised using the Joanna Briggs Institute RCT tool, and synthesised narratively.

Results: Eighteen RCTs involving a total of 20,350 participants were included. Interventions included message framing (7/18), educational programmes (4/18), digital tools (4/18), storytelling (2/18), social media engagement (1/18), community ambassador outreach (1/18), AI-based misbelief correction (1/18), and affective priming (1/18). Educational and digital tools consistently reduced hesitancy and improved confidence. Message framing showed mixed effects with autonomy-affirming improving trust, while loss framing sometimes increased hesitancy. AI and affective priming showed early promise but need further testing. Trust outcomes varied across trials.

Conclusion: Educational and culturally sensitive digital tools were most effective, while framing, social media, and ambassador approaches had mixed impact. Trust gains were inconsistent. Key gaps remain in measurement, follow-up, global diversity, and reporting. Future work should use standardised measures, longer follow-up, broader populations, and evaluate emerging tools like AI for trust-building.

1. Introduction

Recent years have seen the return of death from vaccine-preventable diseases such as measles. In 2025, the United States reported over 1,000 measles cases by May, already surpassing the total number in 2024 (1). Despite the fact that measles was declared eliminated in the U.S. in 2000, declining immunization rates have enabled its return, largely driven by rising vaccine hesitancy (2).

Similar trends are seen globally. In 2024, the European region reported 127,350 measles cases driven by over 500,000 children missing their first MCV1 dose in 2023. The WHO emphasizes that engaging parents and marginalized communities must remain a priority in all immunization efforts (3). This review contributes to that agenda by mapping recent intervention trials to identify which strategies most effectively reduce hesitancy and rebuild public trust.

Falling vaccination coverage has directly weakened herd immunity. In the U.S., kindergarten vaccination rates fell from 95.2% in 2019-2020 to 92.7% in 2023-2024, leaving about 280,000 children at risk. This is below the 95% threshold needed to stop measles from spreading (4). By undermining herd immunity, widespread hesitancy threatens to reverse hard-won gains in combating vaccine-preventable diseases.

The urgency of addressing this issue was further highlighted during the COVID-19 pandemic, when uneven vaccine uptake, often driven by trust deficits, slowed efforts to control a global health emergency (5).

Vaccine hesitancy is formally defined as "*delay in acceptance or refusal of vaccination despite availability of vaccination services*" (6). Recognising its scale, the WHO declared vaccine hesitancy one of the top ten global health threats in 2019 (7).

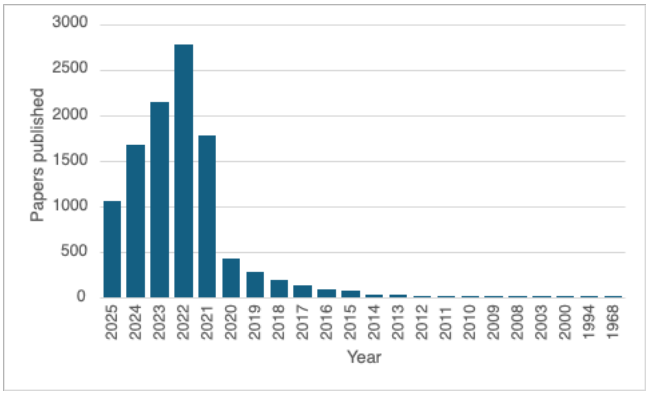


Figure 1: Publications on vaccine hesitancy indexed in PubMed by year (1968–2025).

The term "Vaccine hesitancy" was first used in academic literature in 1994 to describe resistance around immunisation among physicians (8) and it has since evolved to capture a wide spectrum of public attitudes. It began to increase steadily after 2010, particularly following the controversy surrounding the MMR-Autism claims and growing public concern about vaccine safety (9). The most dramatic rise occurred during the COVID-19 pandemic, with publications peaking in 2022 at 2778 PubMed-indexed papers. Since then, output has declined but remains far higher than pre-pandemic levels, reflecting continued recognition of vaccine hesitancy as a major barrier to immunisation programmes.

The causes of vaccine hesitancy are complex. Factors include misinformation spread through social media, politicisation of vaccine campaigns, religious or philosophical objections, and declining confidence in health authorities (10-13). Recent research has also highlighted the global impact of US-based misinformation networks in undermining vaccine confidence in other regions, such as West Africa and Eastern Europe (14).

To better understand these causes in a structured way the World Health Organization (WHO) developed the 3C model which groups the main reasons into three areas (15).

- Confidence refers to concerns about whether vaccines are safe, effective, and whether health authorities can be trusted.
- Complacency reflects the belief that the risk of disease is low, and vaccination is therefore unnecessary.
- Convenience highlights the practical factors that affect how easy it is for people to access and afford vaccines.

Of these, trust emerges as a central determinant. Several empirical studies have shown a strong and direct connection between low trust and high vaccine hesitancy (5, 16-18). This underscores why this review prioritizes trust as a central focus. Building lasting trust is essential as, without it, short-term increases in uptake may prove fragile.

Research into strategies to reduce vaccine hesitancy has grown rapidly, particularly during the COVID-19 pandemic, yet the evidence remains fragmented. Interventions range from communication campaigns and clinician training to community partnerships, mandates, and incentives (19, 20). However, these studies often adopt different definitions of hesitancy, employ varied methods, and target diverse populations, making it difficult to compare results or draw general conclusions about effectiveness.

A further challenge lies in how hesitancy is conceptualised and measured (21). Hesitancy reflects uncertainty and indecision, while intention refers to the plan to get vaccinated. For example, an individual may feel hesitant but still proceed with vaccination or intend to vaccinate but delay. Addressing intention

requires different strategies than addressing hesitancy, which is why this review places hesitancy itself at the centre. We therefore measure hesitancy as the primary outcome and only consider intention where it is explicitly linked to underlying hesitancy.

Although systematic reviews and meta-analyses have expanded rapidly over the past decade, most focus on narrow populations, specific intervention types, or vaccination uptake as the sole outcome. incentives (19, 20, 22). Scoping reviews have been similarly limited, often confined to vaccines or groups, and none have comprehensively mapped randomised control trials (RCT) based interventions across multiple vaccines (23, 24). Moreover, existing reviews typically prioritise uptake, with hesitancy and trust outcomes treated as secondary or overlooked (25, 26). Yet without reducing hesitancy and strengthening trust, short-term increases in uptake are unlikely to be sustained.

This review addresses these gaps by focusing on hesitancy as the primary outcome, with particular attention to public trust and attitudinal change. By synthesising RCT-based interventions, it will identify the most studied strategies, examine how hesitancy and trust are defined and measured, and identify gaps for future research. Given that most reviews cover literature up to 2023 and concentrate on COVID-19, I restricted our scope to 2024–2025 to capture recent post-pandemic interventions. A scoping review is the most appropriate approach, as it enables mapping of the full range of strategies and outcomes.

Aims of this study

1. To map the range of strategies that have been implemented to reduce vaccine hesitancy.
2. To examine the impact of these strategies on vaccine hesitancy, public trust and attitudinal outcomes.
3. To identify knowledge gaps and provide evidence-based insights that can inform policymakers, public health practitioners, and future intervention efforts.

By emphasising trust and hesitancy as primary outcomes, this review goes beyond uptake-focused analyses and complements existing systematic work, highlighting that success in immunisation must be measured not only by increased coverage but by lasting confidence in vaccines and the institutions that deliver them.

2. Method

This review was conducted in line with the Joanna Briggs Institute (JBI) Scoping Reviews Methodology Group guidance and reported according to the PRISMA-ScR checklist (27, 28). The methodology was refined through feedback from a second reader and my academic supervisor from the University of St Andrews.

2.1 Search Strategy

A comprehensive, librarian-assisted search was conducted between 5-6 June 2025 across Scopus, Embase, MEDLINE, Web of science and PsycINFO.

Scopus, Embase, MEDLINE and PscyINFO:

1. (vaccin* OR immuni*) adj3 (hesita* OR accept* OR behavi* OR reject* OR resist* OR refus*).mp.
2. Limit to randomized controlled trial

Web of Science:

1. "vaccine hesitan*"
2. OR ((vaccin* OR immuni*) NEAR/3 (hesita* OR accept* OR behavi* OR reject* OR resist* OR refus*))

3. AND ("randomized controlled trial" OR "randomised controlled trial" OR "RCT")

2.2 Eligibility Criteria

Inclusion and exclusion criteria were prespecified (see Table 1). Eligible studies were RCTs of interventions explicitly designed to reduce vaccine hesitancy, confidence, or trust, targeting the public in any global setting. Uptake or intention outcomes were included only if explicitly linked to changes in hesitancy. I restricted inclusion to studies published in 2024-2025 to capture the most recent strategies beyond pandemic-era evidence and avoid duplication with prior reviews.

Table 1: Inclusion and exclusion criteria used to determine study eligibility for the review.

Domain	Inclusion	Exclusion
Population	General public, any age/region	Healthcare workers; animals/non-humans.
Intervention	Primary aim = Reduce vaccine hesitancy (educational, behavioural, psychological)	Access/logistics/efficacy interventions without attitudinal aim.
Outcomes	Quantitative or qualitative evidence of change in hesitancy, confidence, or trust.	Uptake/intention only; no hesitancy, confidence, or trust outcomes.
Study Design	Randomised control trials.	Non-RCTs; observational/qualitative only.
Language	English.	Non-English.
Context	Any vaccine, any setting.	-
Publication Date	2024-2025.	Outside 2024-2025

2.3 Screening and selection

All search results were imported into Covidence software (29). Automatic and manual deduplication removed 398 references (386 by software, 12 manually). Two reviewers independently screened titles and abstract, applying broad inclusion to capture all potentially relevant interventions. At full-text screening, both reviewers independently assessed eligibility against the pre-defined criteria. Although the original protocol did not include a date restriction, a decision was made after full text screening to include only studies published in 2024-2025, as earlier reviews had covered studies up to 2023, and partly because the Laidlaw programme is limited to a single summer period.

Disagreements at any stage were resolved through discussion, with agreement reached in consultation with the academic supervisor when required.

2.4 Data extraction

Data extraction was conducted in Microsoft Excel using a piloted extraction form (30). Two reviewers, working independently, recorded study characteristics (author, year, country, vaccine type, population), intervention design, comparator, outcomes, key findings and impact on both vaccine hesitancy and trust/attitudes. After extraction, I compared both datasets, identified any discrepancies, and created a single combined table of findings. Oversight and guidance were provided throughout by the academic supervisor.

2.5 Critical appraisal

Two reviewers independently applied the revised Joanna Briggs institute (JBI) critical appraisal tool for randomized controlled trials to all included studies (31). Because many of the RCTs were not presented in a traditional format, some checklist items were open to interpretation; therefore, having two reviewers ensured that the tool was applied rigorously and consistently. I then compared the appraisal tables, consolidated them into a single summary, and discussed any discrepancies with the second reviewer until consensus was reached. Oversight and guidance were provided by the academic supervisor throughout the process.

2.6 Synthesis

Data were synthesised narratively. I organised the extracted data into tables in Excel, grouping studies by the type of intervention, and how they reported trust, confidence and hesitancy. The second reviewer checked these tables for accuracy and completeness, and I resolved any difference through discussion, with input from our supervisor when needed.

3. Results

3.1 Study selection

I identified 846 records from databases (Scopus 346, Embase 236, MEDLINE 135, Web of Science 114, PsycINFO 15). After removing 398 duplicates (Covidence 386 + manual 12), 448 records were screened at title/abstract and 203 were excluded. I sought 244 reports for retrieval; 73 were not retrieved, leaving 171 reports assessed for eligibility. 18 randomized trials were included (cite all studies).

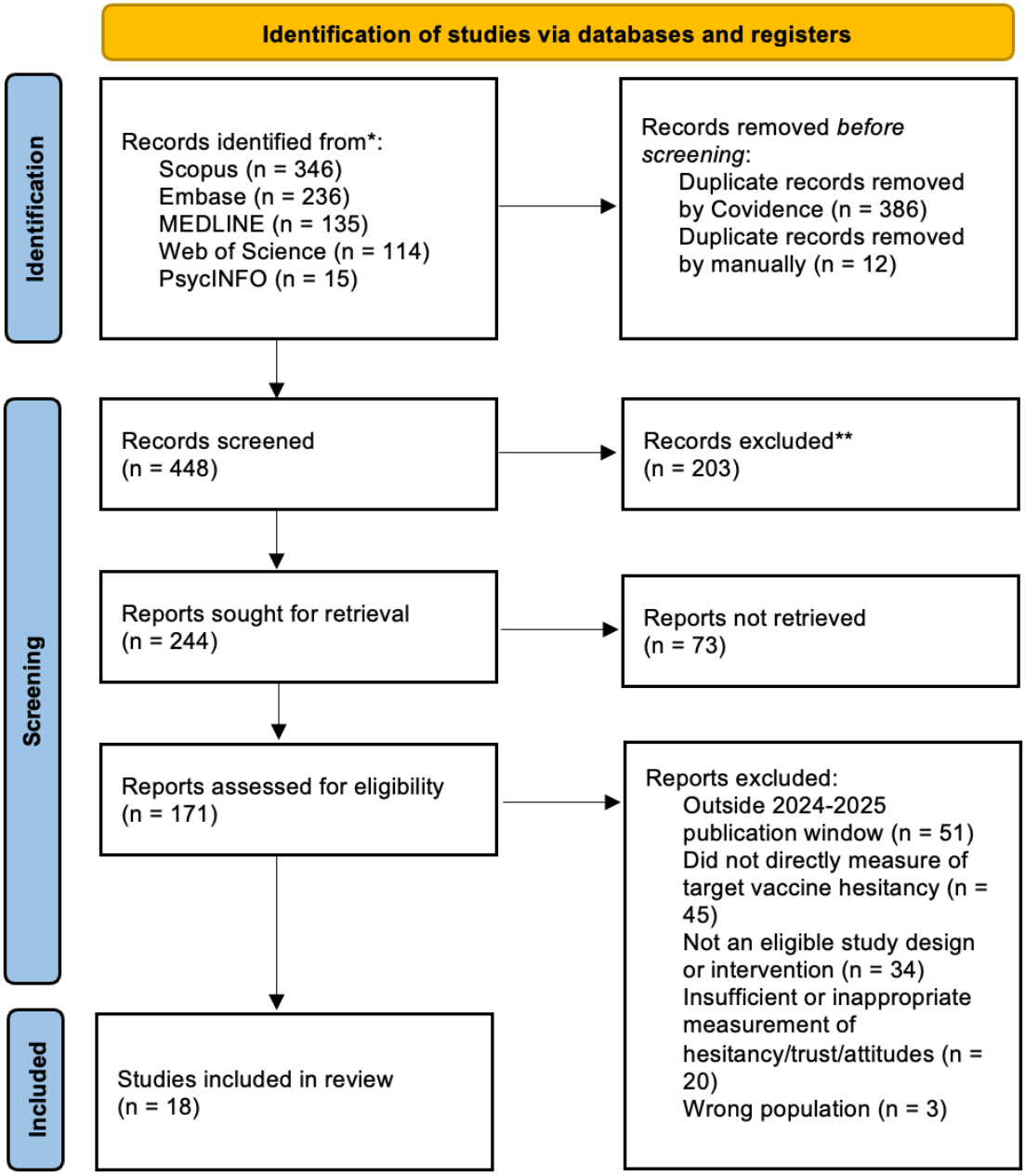


Figure 2: PRISMA chart of the literature search and study selection for the scoping review on randomized controlled interventions to address vaccine hesitancy.

3.2 Reasons for exclusions

Reports not retrieved (n = 73) were grouped as follows:

- Protocol only – no results published as of June 2025 (n = 32)
- No full text found as of June 2025 (n = 14)
- Results not published in a peer-reviewed journal (n = 13)
- Conference or poster abstract only (n = 10)
- Study withdrawn (n = 2)
- Terminated trial – did not reach completion (n = 2)

Reports excluded at full-text stage (n = 102) were grouped as follows:

- Not an eligible study design or intervention (n = 34): Wrong study design (n = 25), no intervention implemented/evaluated (n = 7), wrong aim (n = 2).
- Did not specifically measure or target vaccine hesitancy (n = 45): Intervention not targeting hesitancy (n = 17), only measured uptake (n = 14), or measured intentions without explicit linkage to hesitancy (n = 14).
- Insufficient or inappropriate measurement of hesitancy/attitudes (n = 20: No quantitative measure (n = 9), no data on attitudes/trust/confidence (n = 8), only baseline hesitancy measured (n = 1), no baseline data (n = 2).
- Wrong population (n = 3).

3.3 Study Characteristics

A detailed overview of the 18 included randomized controlled trials is presented in Table 2. All the studies used individual-level randomisation, except for Study 9, which was a cluster randomised design at the village level. Table 2 summarizes each study's characteristics, intervention type, comparator, outcomes assessed, and main findings (32-49).

Table 2: Characteristics and findings of included RCTs

	Study Characteristics (Author, Country, Vaccine Target, Population)	**Intervention + Control**	**Aims of intervention**	**Outcomes measured**	**Impact on vaccine hesitancy**	**Impact on Trust/Attitudes**
1	Abroms et al., 2024 United states COVID-19 N = 478 DOI: https://doi.org/10.1177/10901981231188313 (32)	**Social media** Empathic engagement posts in private Facebook groups, using gist-based framing. Two–three vaccine posts/day for 4 weeks (~60 posts). **Control:** Facebook info centre only, no posts.	To increase vaccine uptake and intention to vaccinate by providing information aimed at eliciting concerns and building trust.	**Primary:** Vaccine uptake, intention to vaccinate, intention to encourage others to vaccinate. **Secondary:** COVID-19 vaccine confidence, sense of responsibility, and engagement with posts.	**Intention (overall):** No significant effect. **Intent (secondary):** Higher in intervention **Uptake:** No significant difference	**Trust:** No change **Confidence:** No change **Attitude:** Small positive findings.
2	Al-Maghaireh et al., 2024 Jordan Measles-Rubella (MR) N = 250	**Message framing** Short text messages on paediatric vaccines, co-designed with rural parents. Framed as autonomy-confirming (choice) vs. authoritarian (authority).	To educate parents and address common myths and cultural beliefs that contribute to vaccine hesitancy through an	Parent Attitudes about Childhood Vaccines (PACV) scores including behaviour, safety and efficacy, and trust subscales.	**Hesitancy:** Significantly reduced	**Trust:** Significant improvement **Attitude:** Positive change

	DOI: https://doi.org/10.1016/j.ajic.2024.05.008 (33)	**Control:** MR informational video (5 min).	educational program aimed at influencing parents' attitudes towards MR.			
3	Atif (Nurzhynska) et al., 2024 Ukraine Measles, Mumps, Rubella (MMR) N = 738 DOI: https://doi.org/10.47368/ejhc.2024.103 (34)	**Message framing** Six email framings: mandatory (control), loss-framed, barrier-reduction, doctor testimonial, social norm (school director), social norm (family doctor). **Control:** Mandatory vaccination letter.	To positively impact vaccination attitudes, intention and behaviours related to MMR vaccinations through message framing.	Change in vaccine-related attitudes, vaccine-scheduling intention and appointment scheduling behaviour of mothers.	**Intention:** No significant effect. **Hesitancy:** No effect with national template. Normative letters may increase uptake.	**Attitude:** Modest positive improvement
4	Béchard et al., 2024 Canada COVID-19 N = 525 DOI: https://doi.org/10.2196/52871 (35)	**Message framing** Exposure to matched-length vaccine articles, varying by writing style (journalistic vs. ideological) and layout (with/without visuals). **Control:** Neutral article (JW/Id × layout).	To evaluate the role of reinformation influence COVID-19 vaccine hesitancy, vaccine attitudes, perceived uncertainty, and confidence in vaccination.	**Primary:** Perceived tentativeness of information shared and confidence in COVID-19 vaccination. **Secondary:** General attitude toward vaccination."	**Hesitancy:** No significant change. Shaped mainly by preexisting attitudes.	**Trust:** No significant improvement from the intervention. Shaped mainly by preexisting attitudes. **Attitude:** Significant moderate effect. **Confidence:** No direct improvement. Higher only among those already pro-vaccine.
5	Byerley et al., 2024 United states COVID-19 N = 400 (May) DOI: https://doi.org/10.1038/s41598-024-57841-1	**Educational intervention** Interactive web app (Relative Risk Tool) comparing vaccine vs. infection risks with sliders, visual aids, and everyday risk comparisons.	To investigate whether the Relative Risk Tool influences risk perception and increases intent to receive the COVID-19 vaccine.	Perceived risk of vaccination vs infection. Intent to receive a COVID-19 vaccine in the future. Trust in source.	**Hesitancy:** Reduced **Intention:** Increased	**Trust:** Significant improvement (increased)

	(36)	**Control:** CDC vaccine info (May)				
6	Carlson et al., 2025 Spain and Bulgaria Influenza (flu) N = 2000 DOI: https://doi.org/10.1038/s41598-025-96092-6 (37)	**Information exposure** Electronic product information with salience manipulation: no ePI, standard, positive highlight, negative highlight, or both. **Control:** No ePI.	To determine how the provision and salience of electronic product information (ePI) affects vaccine hesitancy.	**Primary:** Vaccine hesitancy **Secondary:** Reading time, Risk perceptions and trust.	**Hesitancy:** Increased in all ePI groups	**Trust:** No change **Attitude:** Positive improvement
7	Cotter et al., 2025 United states COVID-19 and influenza (flu) paediatric vaccines N = 1718 DOI: https://doi.org/10.1016/j.vaccine.2025.126947 (38)	**Message framing** Text + visual vaccine messages framed as autonomy-confirming vs. authoritarian, co-designed with rural parents. **Control:** No message (not detailed).	To test whether autonomy-confirming messaging and alignment with political beliefs improve parental vaccine confidence, attitudes and intention to vaccinate children.	Vaccine confidence and Vaccine intention.	**Hesitancy:** Reduced among conservative parents with autonomy-affirming messages. **Intention:** Increased in conservatives for flu only. Liberals already high, unaffected by message style.	**Confidence:** Higher with autonomy-confirming messages (especially conservatives) in both flu and COVID.
8	Flusberg et al., 2024 United States COVID-19 N = 301 DOI: https://doi.org/10.1371/journal.pone.0294739	**Message framing** Explanatory messages using extended metaphors (e.g. raincoats, seatbelts) vs. literal health messages. **Control:** Literal (non-metaphor) messages.	To test if there is a relationship between explanatory metaphors in public health messaging and positive effects on vaccine attitudes, understanding	Participant beliefs and attitudes towards vaccination using (a) the Vaccination Attitudes Examination Scale, (b) the Vaccine Hesitancy Scale, and (c) the Vaccine	**Hesitancy:** Modestly reduced across all groups.	**Trust:** Not increased, but intervention improved attitudes even in low-trust groups. **Attitude:** Positive improvement

	(39)		and help address misconceptions.	Conspiracy Beliefs Scale.		across all groups.
9	Islam et al., 2024 Indonesia COVID-19 N = 3254 DOI: https://doi.org/10.1016/j.euroecorev.2024.104683 (40)	**Ambassador outreach** Door-to-door visits with ambassadors (health volunteers, local influencers, or laypersons) delivering vaccine info with pamphlets. **Control:** Layperson ambassador reference.	To assess whether personalized, door-to-door information from local ambassadors can counter misinformation, reduce COVID-19 vaccine hesitancy, and increase uptake.	**Primary:** Vaccine take-up, registration and intent. **Secondary:** Mental health (General and COVID-specific), compliance with health protocols, and beliefs.	**Hesitancy:** Small decrease observed across all groups. **Drivers:** Misconceptions and misinformation remained the main factors, though slightly less prominent post-intervention. **Take-up:** No increase in vaccine registration. Type of ambassador had no effect.	**Trust:** No change across groups, despite some ambassadors rated more trustworthy. **Attitudes:** No improvement.
10	Jibril et al., 2024 Pakistan COVID-19 N = 440 DOI: https://doi.org/10.47391/JPMA.20108 (41)	**Educational intervention** COVID-19 education tool adapted from hospital FAQs, provided in English/Urdu before questionnaire. **Control:** No tool before questionnaire.	To determine if an educational intervention can reduce COVID-19 vaccine hesitancy and resistance among visitors to a tertiary care hospital in a developing country.	Vaccine hesitancy/resistance, belief in conspiracy theories, and perceptions of COVID-19 illness, vaccine effectiveness, and vaccine safety.	**Hesitancy:** Decreased **Resistance:** Decreased	**Confidence:** Significantly increased. **Attitude:** Positive improvement through reduced misconceptions and conspiracy beliefs.

11	Lu, 2025 United States COVID-19 N = 1435 DOI: https://doi.org/10.1016/j.vaccine.2025.127018 (42)	**Artificial intelligence** AI-generated correction messages tailored to traits (extraversion, pseudoscientific beliefs) vs. generic correction and control. **Control:** Non-vaccine Reuters correction.	To reduce belief in vaccine-related misbeliefs using generative AI messages and assess their impact on vaccination attitudes.	Vaccine misbeliefs and general vaccine attitudes.	**Hesitancy:** Improved with generic and personality-matched messages. **Misbeliefs:** Decreased across all intervention groups, strongest in generic and extraversion-targeting conditions.	**Attitudes:** No overall change. Slight improvement in low-belief groups. Backfire in high-belief groups.
12	Mancuso et al., 2025 United States (Alabama, Georgia & North Carolina) COVID-19 N = 360 DOI: https://doi.org/10.2196/67370 (43)	**Storytelling** Mobile app with digital storytelling, interactive activities, and tailored health messages, developed with community input. **Control:** CDC standard info.	To empower informed COVID-19 vaccination decisions and identify Black young adult subgroups most responsive to the TT-C intervention for targeted strategies.	**Primary:** COVID-19 Vaccine uptake. **Secondary:** Vaccine hesitancy, Vaccine confidence, Vaccine-related conspiracy belief, vaccine knowledge and group-based medical mistrust.	**Hesitancy:** Decreased in resistant and neutral groups, with TT-C DHI showing the greatest overall improvements. No change in receptive group. **Uptake:** No significant difference.	**Confidence:** Increased in resistant and neutral groups. No change in receptive group. **Attitudes (conspiracy beliefs):** Decreased in resistant and neutral groups.
13	Qin et al., 2024 United States COVID-19 (mRNA booster, Pfizer/Moderna) N = 1409 DOI: https://doi.org/10.3390/vaccines12091066 (44)	**Educational intervention** Participants read safety-focused, effectiveness-focused, or no vaccine explanation. **Control:** No explanation.	To reduce COVID-19 booster hesitancy by increasing trust in science and understanding of booster safety and effectiveness.	**Primary:** Booster intention **Secondary:** Perceived booster safety/effectiveness, emotions and omission bias. Trust in scientists, mRNA technology, and traditional vaccines. **Moderating:** Political ideology	**Hesitancy:** Decreased in both groups. **Willingness:** Increased in both groups.	**Trust:** Increased, especially among conservatives. **Attitudes:** Improved expertise and hope. Fear unchanged.

14	Redd et al., 2024 United States Human Papillomavirus (HPV) vaccine N = 1241 DOI: https://doi.org/10.1007/s10900-024-01327-8 (45)	**Storytelling** Video intervention: survivor testimonial (religious framing), informational HPV facts, or control adenovirus video. **Control:** Adenovirus video.	To assess whether a culturally tailored Christian-focused video can increase HPV vaccine intentions and address hesitancy.	**Primary:** Vaccine intention. **Secondary:** Change in belief, positive attitudes toward vaccines, HPV knowledge, vaccine knowledge and trust in modern medicine.	**Intention:** Increased in HPV-hesitant individuals with both religious and informational videos. **Hesitancy:** No change overall.	**Attitudes:** No significant change in general vaccine attitudes. Improved HPV-specific beliefs and intent. Cultural shift in "family values protect" belief.
15	Rinaldi et al., 2025 France and Italy COVID-19 N = 1068 DOI: https://doi.org/10.1016/j.healthpol.2025.105301 (46)	**Message framing** Articles on vaccine-related thrombosis framed as abstract (scientific) vs. concrete (anecdotal). Some groups primed with categorization tasks. **Control:** Questionnaire only.	To assess how vaccine adverse events and abstract vs. concrete loss-framed messages influence hesitancy, gender responses, and shifting vaccine preferences.	**Primary:** Vaccine willingness **Secondary:** Perceived COVID-19 and vaccine risk. Expected vaccine benefit, behavioural category classification, and gender differences in framing response.	**Hesitancy:** Increased in both France and Italy, consistently higher in France. **Framing:** Abstract loss-framing produced stronger hesitancy than concrete framing; vaccine preferences unstable over time. **Demographics:** Women showed lower hesitancy than men.	**Attitudes:** Loss-framed messages backfired, with women more hesitant after abstract framing and men less willing after concrete framing.
16	Shi et al., 2024 China Human Papillomavirus (HPV) vaccine N = 4012 DOI: https://doi.org/10.1111/bjhp.12759	**Message framing** Eight message variations: gain vs. loss framing, individualism vs. collectivism, narrative vs. non-narrative, or neutral control. **Control:** Neutral HPV info (China).	To test how different message framings affect HPV vaccine hesitancy and intention.	**Primary:** Change in HPV vaccine hesitancy score (ΔVH). **Secondary:** Perceived risk of infection, social norms, and perceived behavioural control."	**Hesitancy:** Decreased overall, with loss-framing most effective but sometimes backfiring among high-hesitant groups.	**Trust:** Small increase in perceived control with individualist and non-narrative messages. **Attitudes:** No change in social

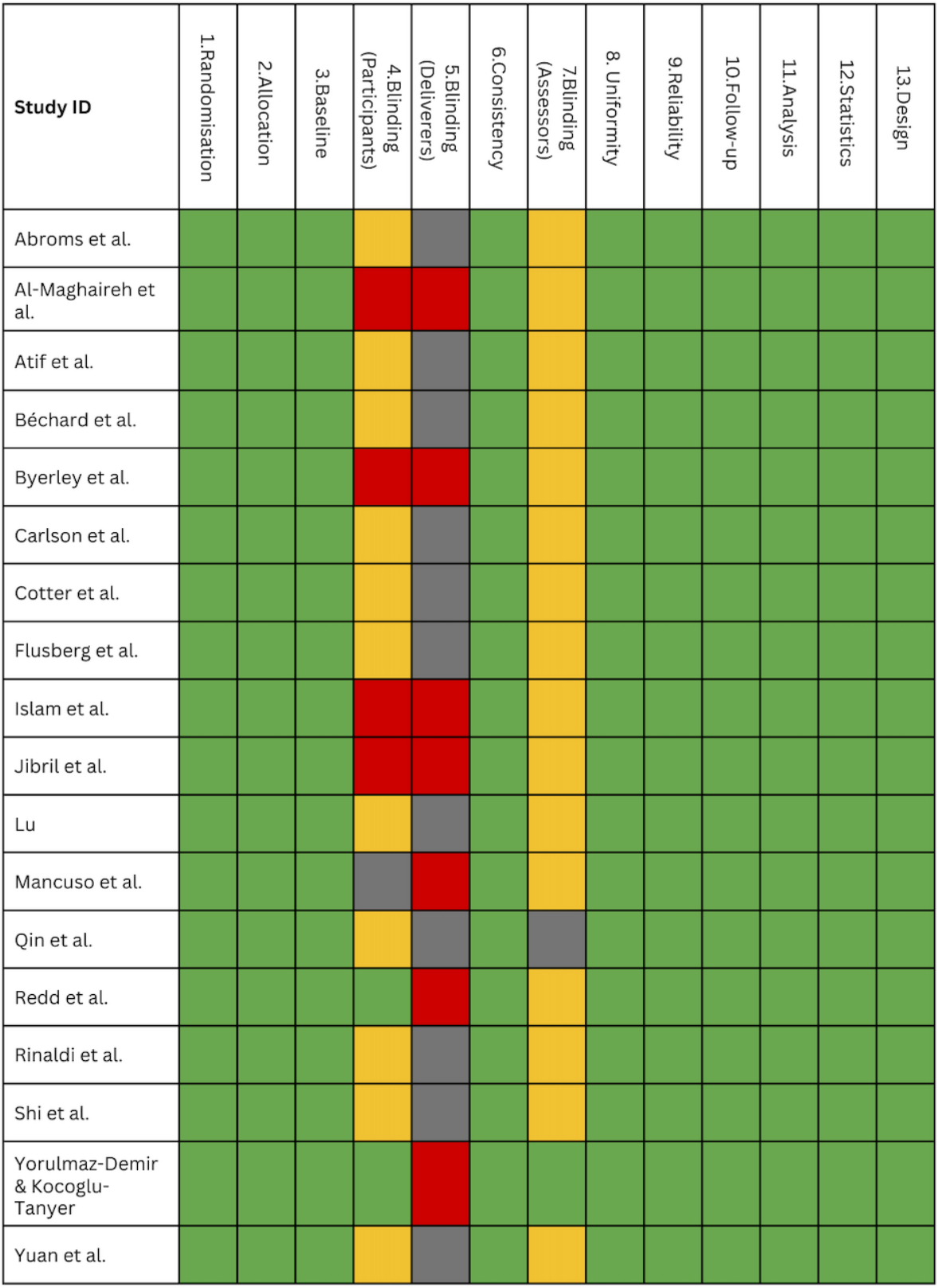
	(47)				**Incentives:** Had no effect; framing worked only for low-hesitant parents.	norms or perceived risk.
17	Yorulmaz-Demir & Kocoglu-Tanyer, 2025 Turkey Turkey General childhood vaccines (Including measles and tetanus) N = 74 DOI: https://doi.org/10.1016/j.pedhc.2024.11.012 (48)	**Educational intervention** Four-session program covering vaccine literacy, hesitancy, and advocacy, with activities like brochures and peer education. **Control:** No intervention.	To improve mothers' vaccine literacy and advocacy intentions through an education program based on the I-Changed Model.	**Primary:** Change in vaccine literacy, vaccine attitude, and vaccine advocacy. **Secondary:** Change in mothers' vaccine knowledge.	**Hesitancy:** Not directly measured, but predictors improved. **Conclusion:** Strengthening advocacy intentions may help reduce community hesitancy.	**Attitudes:** Positive improvement. Education program boosted literacy and advocacy, strongest among mothers.
18	Yuan et al., 2025 Hong kong COVID-19 N = 647 DOI: https://doi.org/10.1111/bjhp.12808 (49)	**Affective priming** Guided imagery tasks inducing positive emotions while reading vaccine news, to reduce negative processing. Control: Neutral recall task."	To reduce parental vaccine hesitancy by decreasing negative processing of pandemic, vaccine information and concerns about safety through a positive imagination intervention.	Affective response to pandemic and vaccine-related news, vaccine intention, vaccine-hesitant attitudes (PACV), vaccine acceptance and trust and concern.	**Hesitancy:** No significant change overall	**Trust:** Improved in vaccine information. Safety concerns slightly reduced. **Attitudes:** Distress indirectly lowered acceptance through negative emotional responses.

3.4 Critical appraisal

The quality of studies was mixed (Table 3). Blinding of participants, deliverers, and outcome assessors was consistently weak or unclear due to reliance on self-reported attitudes and the nature of behavioural interventions. For online interventions (e.g., digital tools, message framing), blinding was not applicable. Randomization and baseline comparability were generally well reported, though details on allocation concealment and blinding were often absent. Overall, the main problem with bias was poor blinding,

which is difficult in vaccine hesitancy trials but could be improved if studies reported methods more clearly.

Table 3: Critical appraisal of included RCTs using the revised JBI tool



Bias related to selection and allocation:

1. Was true randomization used for assignment of participants to treatment groups?
2. Was allocation to treatment groups concealed?
3. Were treatment groups similar at the baseline?

Bias related to administration of intervention/exposure:

4. Were participants blind to treatment assignment?
5. Were those delivering the treatment blind to treatment assignment?
6. Were treatment groups treated identically other than the intervention of interest?

Bias related to assessment, detection, and measurement of the outcome:

7. Were outcome assessors blind to treatment assignment?
8. Were outcomes measured in the same way for treatment groups?
9. Were outcomes measured in a reliable way?

Bias related to participant retention:

10. Was follow-up complete and, if not, were differences between groups in terms of their follow-up adequately described and analysed?

Statistical conclusion validity:

11. Were participants analysed in the groups to which they were randomized?
12. Was appropriate statistical analysis used?
13. Was the trial design appropriate and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?)

3.5 Overview of findings

Across the 18 included RCTs, interventions could be grouped into eight main types. The most common approach was message framing (7/18, 39%), which included autonomy-affirming texts, gain/loss frames, metaphors, and culturally adapting framings (33, 47). Educational interventions accounted for 4/18 studies (22%) and typically involved structured tools, apps or multi-session programs to increase literacy and confidence. Storytelling approaches (2/18, 11%) used survivor testimonials or digital narratives to influence attitudes. Less common strategies included social media engagement (1/18, 6%), ambassador outreach in communities (1/18, 6%), artificial intelligence-based misbelief correction (1/18, 6%), and affective priming with positive imagination (1/18, 6%).

In terms of vaccine types, most interventions (11/18, 61%) targeted COVID-19 vaccines, including booster uptake and combined paediatric COVID-10 and influenza messages. Other vaccine types were HPV (2/18, 11%), measles/MMR/MR (2/18, 11%), influenza (1/18, 6%), and general childhood vaccines (2/18, 11%).

Geographically, just over half of studies were conducted in North America (9,18, 50%), with eight from the United States and one from Canada. Europe contributed 3/18 (17%) studies including Spain and Bulgaria, France and Italy, and Ukraine). Asia contributed another 3/18 (17%) including China, Hong Kong and Pakistan. The Middle east accounted for 2/18 (11%) including Jordan and Turkey and Southeast Asia for 1/18 (6%) including Indonesia.

Regarding target populations, nearly half the studies recruited the general adult population (8/18, 44%), across settings ranging from the U.S. to Pakistan and France/Italy. Parents were the focus in 5/18 trials (28%), including Jordanian and Chinese parents and U.S. caregivers. Three studies (17%) specifically targeted vaccine hesitant groups, such as black young adults in the U.S. south (Mancuso 2025) and rural Indonesian adults (Islam 2024). One trial (6%) recruited a culturally specific subgroup of Christian parents in the United States (Redd 2024).

4. Discussion

This scoping review sought to map strategies designed to reduce vaccine hesitancy, examine their impact on hesitancy, trust, and attitudinal outcomes, and identify knowledge gaps to guide future policy and practice. This scoping review identified diverse strategies to reduce vaccine hesitancy, but their effectiveness varied.

4.1 Summary

Educational programmes and digital tools showed the strongest and most reliable results. For example, apps that compared vaccine risks (36) and hospital FAQ systems (41) consistently reduced hesitancy, boosted confidence, and helped correct false beliefs. These methods are practical to expand, can be adapted for different vaccines, and seem less likely to backfire than message-framing approaches.

Message framing, the most tested method, gave much more mixed results. Autonomy-affirming messages worked well for conservative parents by increasing trust and intention (38), but loss-focused messages sometimes had the opposite effect and increased hesitancy (46). This suggests framing strategies need to be carefully tailored to different groups instead of being applied broadly.

Some newer approaches are promising but still uncertain. A Facebook group trial (32) encouraged discussion but did not increase vaccine uptake, and community ambassador schemes in Indonesia (40) only slightly reduced hesitancy without leading to more registrations. These strategies may work better if they involve longer-term engagement or trusted local leaders.

Emerging innovations such as generative AI corrections (42) and affective priming (49) highlight new directions for behavioural vaccine research. One study using generative AI (42) found that tailored messages reduced false beliefs, especially when matched to personality traits, although they sometimes reinforced negative views among people already strongly opposed to vaccines. A complementary pilot study in Hong Kong with an AI assistant ("Auricle") improved vaccine knowledge and confidence, though changes in hesitancy scores were limited (50).

Together, these results suggest AI may be better at building confidence and tackling misinformation than directly changing behaviour. Another study (49) tested affective priming, which shifts people's emotional reactions to vaccine information, and showed early promise in improving trust and easing safety concerns. Both AI and priming need more research before being widely used, but they could complement more established approaches. Costello notes that large language models may soon act as everyday health tools, and our findings suggest they should support trust-building interventions rather than replace them (51).

Finally, it is important to note that none of the studies showed both a reduction in hesitancy and an increase in actual vaccine uptake. While some interventions improved attitudes or intentions (36, 41, 44), those that measured uptake directly (32, 41, 43) reported no significant effect.

4.2 Key findings related to trust

Trust was one of the main outcomes examined in this review, and findings were mixed. The strongest improvements came from interventions that used empathy and cultural sensitivity. For example, a Facebook group trial (32) reduced hesitancy by validating concerns, and a culturally tailored HPV video in U.S. Christian communities (45) significantly improved vaccination intentions and positive attitudinal changes.

These findings reflect wider evidence showing that credibility and cultural identity strongly shape vaccine attitudes. Kaddeer et al. found higher mistrust among South Asian pregnant women in the UK compared with Caucasian peers (52), while Larson & Piatek showed how U.S.-based misinformation has weakened confidence internationally shorter (14). Panthagani et al. noted that many health professionals are not

trained to communicate effectively in a social media–driven environment. This gap limits their ability to counter misinformation and weakens the trust needed for interventions to reduce hesitancy (53). Taken together, this suggests that trust can only be strengthened when interventions directly address these underlying gaps in credibility.

4.3 Inconsistencies in Measuring Vaccine Hesitancy

A key issue identified in this review is the inconsistency of outcome measures. Some trials used validated hesitancy scales (36, 37) while others relied on intention, literacy, or related outcomes, which limits comparability. Researchers such as Tuckerman stress that reliable tools already exist, like the PACV, Vaccine Confidence Scale, and 5C scale, but they are not used consistently (54). There is also confusion about what 'hesitancy' means. As Larson explains, it is best seen as uncertainty about vaccination, yet some studies equated it with outright refusal or delay (55). Without a clear definition and standard way of measuring trust and hesitancy, it is difficult to judge if interventions really work. Developing consistent measures should be a key priority for future research.

4.4 Gaps in knowledge

While this review highlights promising strategies, several gaps remain. This review found several important gaps. First, very few studies looked at whether interventions led to more people getting vaccinated. Most relied on self-reported hesitancy, trust, or intention, but only three trials (36, 41, 44) measured real uptake and none showed improvement. This reveals a major gap between attitude change and behaviour.

Second, most studies only tracked outcomes for a short time, so it is unclear if positive effects last or fade. Third, the evidence is dominated by high-income countries, especially the United States, with very little research in low- and middle-income settings where hesitancy and barriers are often greatest.

Finally, reporting standards were often weak. Many papers failed to explain how participants were allocated or whether blinding was used, which makes it harder to judge reliability.

Future research should therefore measure actual vaccine uptake alongside hesitancy-related attitudes, use longer follow-up periods, recruit more diverse populations, and report methods more clearly.

4.5 Limitations

This review has some limitations. First, it only included randomized controlled trials published during 2024–2025. While this ensured high-quality evidence, it may have excluded relevant earlier studies or non-randomized evaluations. Second, most outcomes were self-reported, which may be affected by bias or social desirability, and this limits comparability across studies. Third, the review relied on what was reported in the published papers. Where details such as allocation concealment or blinding were missing, studies had to be rated as "unclear," even if these processes may have taken place. Finally, because of the broad range of interventions and outcomes, results could not be pooled in a meta-analysis and are presented descriptively.

5. Conclusion

This review mapped a diverse range of interventions and found that the most effective strategies were those that combined clear education with cultural sensitivity and trust-building dialogue. Message-framing on its own rarely sufficed, while digital and AI-driven tools showed potential but remain in early stages of evidence development. Addressing vaccine hesitancy therefore requires more than information delivery. It demands sustained investment in trust, credibility, and communication capacity, alongside innovation in digital and AI tools. Future interventions should prioritise standardised evaluation, cultural tailoring, and integration of emerging technologies into public health systems.

Acknowledgement

I would like to thank Lord Laidlaw for supporting my research and leadership journey through the Laidlaw Scholars Programme. I am also very grateful to Professor Frank Sullivan for his supervision and guidance, and to Adelaide Gossling for her helpful feedback as my second reader.

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