Informational briefing followed by LLM-guided motivational interview increases MMR vaccination intent among hesitant parents

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1 Abstract

Background: MMR vaccination rates are declining in the U.S. (1), contributing to recent measles outbreaks. If the decline continues, we risk the return of endemic measles, along with other vaccine-preventable diseases. Evidence-based, scalable approaches to support hesitant parents are needed.

Methods: We ran a preregistered two-arm online randomized controlled trial (Prolific, August-September 2025) among MMR-hesitant U.S. parents. Participants with baseline intention ≤ 6 (1–7 scale) were randomized 1:1 to: (i) Experimental, a timer-gated four-panel MMR carousel followed by an LLM-guided motivational interview, or (ii) Active Control, a format-matched car seat safety carousel and chat. The primary outcome was post-intervention MMR intention adjusted for baseline using ANCOVA (HC3 robust SEs). Sensitivity included a rank-inverse-normal (RIN) transform and exclusion of two borderline low-quality cases. An exploratory analysis of the durability of the effect used delayed post-intent from a follow-up survey on a separate sample of participants.

Results: Among N = 180 randomized participants, the adjusted arm effect (Treatment vs Control) was $\beta \approx 1.03$ points (95% CI 0.72–1.34) on the 1–7 scale. In the follow-up sample (N = 66), the adjusted effect was positive and of similar magnitude ($\beta \approx 1.09$; 95% CI 0.52–1.66). Sensitivity analyses yielded consistent inferences.

Conclusions: A brief appointment-framed MMR content review plus LLM conversation produced a clear increase in vaccination intention relative to a structure-matched active control, with encouraging signs of short-term durability. These findings motivate pragmatic trials testing real-world vaccination uptake.

2 Introduction

As childhood vaccination rates continue to fall, epidemiologists warn that diseases that had been largely eliminated by vaccination can quickly re-establish themselves as endemic. Realistic scenarios project large resurgences with substantial morbidity if coverage slips further (2).

Prior work on vaccine chatbots has shown mixed but promising results across COVID-19 and HPV contexts, including a large cluster RCT with parents in China and MI-oriented AI assistants that improved vaccine attitudes in adult samples (3–7).

Further exploration of scalable, empathetic communication tools is needed. A prior trial we conducted showed that both timer-gated review of CDC-style static content and conversation with a frontier LLM (large language

model) can nudge intention upward (8). Here we combine these two approaches and compare the refined intervention head-to-head against an active control focusing on unrelated, non-vaccine-related content (car seat safety). The goal was to test whether hesitant parents report higher intention to vaccinate after a short content review plus a motivational-interviewing style LLM conversation.

3 Methods

3.1 Study Design

This was a two-arm randomized online experiment. We targeted N = 170 (85/arm) to detect a standardized between-arm effect of d = 0.20 with $\alpha = 0.05$ (two-sided) and 80% power using an ANCOVA framework that adjusts for baseline, assuming pre–post correlation $r^2 = 0.79$ from a prior RCT (8).

3.2 Preregistration

The experiment was preregistered on August 15, 2025 on OSF: Using Conversational AI to Support Parental MMR Decision-Making: An Active-Control Randomized Trial.

3.2.1 Deviations

1. A coding error resulted in the post-intervention survey not being shown to the first cohort of participants. A follow-up survey was conducted to collect delayed post-intent from the affected participants. The resulting sample was used to estimate the durability of the effect as an exploratory analysis, but was excluded from the primary analysis.
2. When recruitment slowed, the study was relaunched on Prolific with higher compensation to reach the target sample size in a reasonable period of time. The initial compensation was $2.50 for completion of the study. Two additional batches were needed at $3.50 and $4.50, respectively, to collect the full preregistered sample.

3.3 Participants & Recruitment

U.S.-resident parents of at least one child born in 2019 or later who had previously indicated less than complete confidence in vaccine safety were recruited on Prolific. To focus on parents who were not already certain to vaccinate, participants who clicked "No concerns about MMR" at a mock appointment confirmation screen exited early; those at ceiling (7 of 7) on baseline intention also exited. The remainder (baseline ≤ 6) were randomized.

3.4 Setting and Dates

Recruitment was conducted online via Prolific, with participants completing the study on a custom web platform. Recruitment and data collection time windows are detailed in Table 1.

Table 1: Recruitment batches and dates.

Batch	N	Launch date	Completion date	Notes
1	90	2025-08-18	2025-08-20	Post-intent not collected
2	77	2025-08-21	2025-08-29	Compensation $2.50

Batch	N	Launch date	Completion date	Notes
3	58	2025-08-29	2025-09-03	Compensation $3.50
4	45	2025-09-03	2025-09-09	Compensation $4.50

3.5 Randomization and Allocation Concealment

Assignments used stratified minimization within baseline-intention strata (1–2, 3–4, 5–6) implemented server-side in the study application. For each eligible participant, the algorithm selected the arm(s) with the current minimum count in the relevant stratum. If a single arm uniquely minimized imbalance, it was assigned. If multiple arms were tied, a uniform pseudorandom tiebreaker (`Math.random()` in JavaScript) selected among the tied arms with equal probability. For auditability, the application logged the tied arm set, arm counts within stratum, the raw random draw value, the derived index, and the assigned arm. Participants were not blinded to topic content after assignment. Investigators responded to limited participant messages for administrative purposes (e.g., assisting with assigned login credentials) and did not engage on study content.

3.6 Intervention

Experimental: a brief timer-gated MMR content carousel followed by an LLM chat using a motivational-interviewing style. Control: parallel structure and engagement, car seat safety content.

Engagement rules were enforced according to the pre-specified plan. The static content carousels included four panels with a per-panel minimum time exposure and scroll-through required. The LLM conversations required participants to accrue ≥ 100 chat-points over ≥ 3 user turns, where `chat_points` was defined as `(chat_turns × 10) + (chat_user_chars × 0.5)`.

3.7 LLM Configuration

Conversations used Claude 4.0 Sonnet via the Anthropic API (model `claude-sonnet-4-20250514`). Generation settings: `temperature=1`, `max_tokens=4096`, `thinking=true`. Prompts steered the LLM towards motivational-interviewing-style interaction with emphasis on parental autonomy. Basic demographic facts and pre-intervention intent scores for each participant were provided as context to the LLM, along with a short briefing on relevant news that happened after the model knowledge window cutoff (e.g., the details of the 2025 measles outbreak in Texas). The LLM opened each conversation. The full system prompts are proprietary; we disclose model/version, generation settings, and engagement rules to support reproducibility.

3.8 Outcomes

Primary outcome: post-intervention MMR vaccination intention (1–7), adjusted for baseline intention.

3.9 Statistical Analysis

We fit an ANCOVA via ordinary least squares with HC3 heteroskedasticity-robust standard errors (two-sided α=0.05).

Model: $\text{post}_i = \beta_0 + \beta_1 \cdot \text{Arm}_i + \beta_2 \cdot \text{pre}_i + \varepsilon_i$

- post_i: participant i's post-intervention MMR intention (1–7)

- pre_i: baseline intention (1–7)
- Arm_i = 1 for Treatment, 0 for Control

The primary estimand is β , the adjusted Treatment–Control difference on the original 1–7 scale. Inference used HC3 robust SEs (Wald t-tests and 95% CIs). Directional expectation was $\beta > 0$, but tests were conducted two-sided.

As an exploratory durability analysis, we fit the same ANCOVA using delayed post-intent in the rescue sample.

All analyses used R 4.5 with renv-pinned packages. Additional robustness results (RIN transformation, exclusion of two borderline cases), residual diagnostics, Arm×Batch interactions, and baseline balance tests are reported in the public analysis notebook.

3.10 Analysis Population and Missing Data

The confirmatory analysis followed an intention-to-treat (ITT) approach within the cohort for whom the primary outcome was collected (N = 180): all randomized participants were analyzed as assigned, with no exclusions for adherence or engagement and no imputation (complete outcome ascertainment in this cohort). An earlier randomized batch (n = 90) did not receive the post-intervention outcome due to a survey display error and was not included in the confirmatory analysis; those participants were recontacted and analyzed as a separate exploratory durability sample.

3.11 Ethics

This behavioral online experiment qualifies for exemption under U.S. 45 CFR §46.104(d)(2)(i) (*benign behavioral interventions with adult participants*). The investigator completed a written self-certification (included in the preregistration materials) attesting that: (i) all participants were ≥18 years; (ii) interventions (reviewing brief content or conversing with an information tool) were brief, harmless, and not offensive or embarrassing; (iii) data were recorded without direct identifiers (only anonymized Prolific IDs); (iv) no deceptive procedures likely to cause harm were used; and (v) risk did not exceed that ordinarily encountered in daily life or routine surveys. Participants provided online informed consent prior to any procedures. No adverse events or harms were reported.

4 Results

4.1 Participant Flow

Of 497 participants who reached the mock-appointment screen in the confirmatory analysis sample, 213 indicated they had questions or concerns about the MMR vaccine. Of those, an additional 33 (15.5%) indicated that they were already at the ceiling ("7 — definitely yes") and exited early. The remaining 180 (36% of those who saw the mock appointment screen) had baseline ≤ 6 and were randomized. Arm allocation was balanced across batches, and baseline intention was similar by batch.

A CONSORT-style participant flow diagram is shown in Figure Figure 1; full recruitment accounting tables are included in the public analysis notebook.

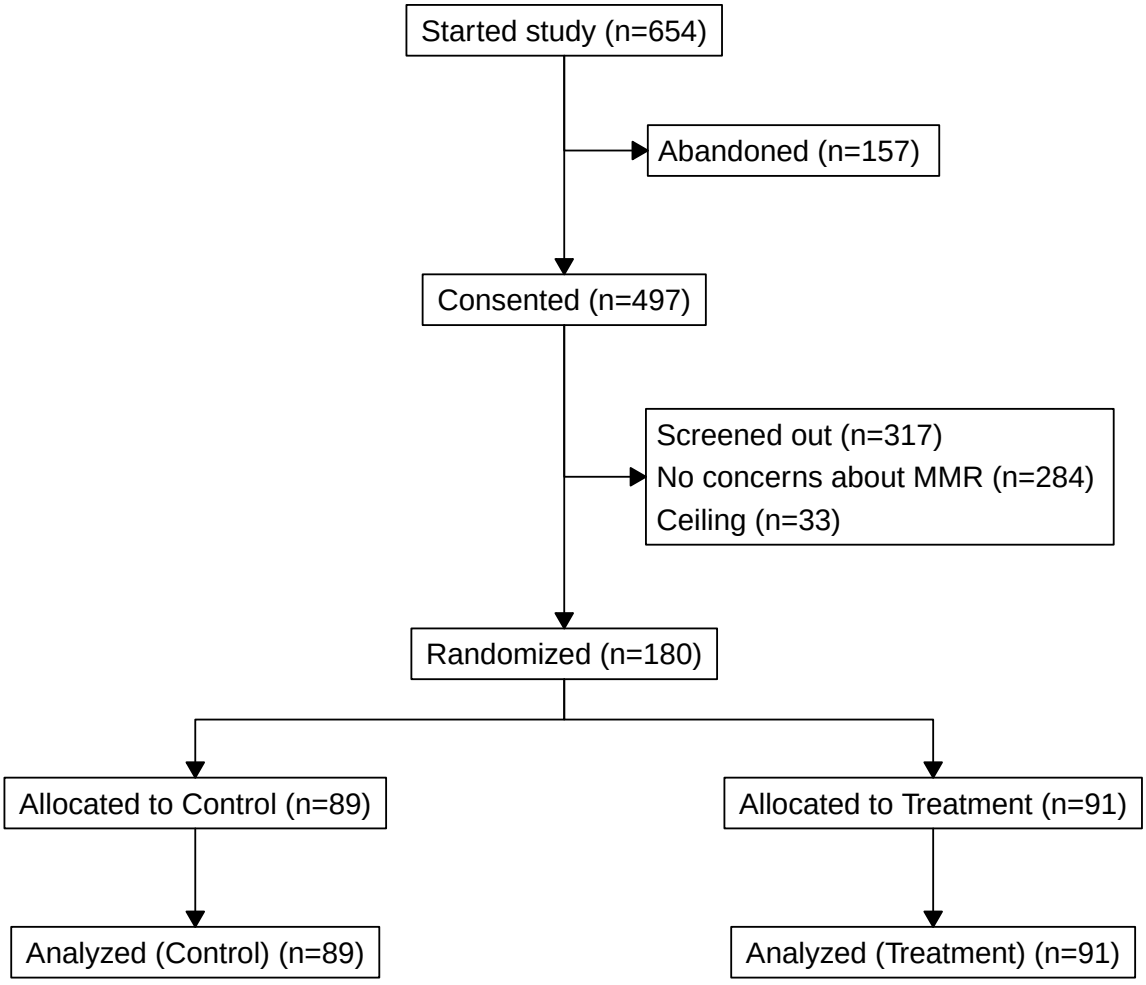

Figure 1: CONSORT flow diagram for participant screening, exclusion, allocation, and analysis.

4.2 Participant Characteristics

Table 2 summarizes participant demographics. Most participants were between the ages of 25 and 34, female, and conservative on the political spectrum.

Table 2: Participant characteristics (overall).

Characteristic	Level	N	Percent
Age	25–34	92	51.1%
	35–44	62	34.4%
	45–54	14	7.8%
	18–24	8	4.4%
	55–64	4	2.2%
Gender	Female	124	68.9%
	Male	55	30.6%
	Prefer not	1	0.6%
Ideology	Conservative	93	51.7%
	Moderate	52	28.9%
	Liberal	32	17.8%
	Prefer not	3	1.7%

4.3 Primary Outcome

The adjusted arm effect was $\beta \approx 1.03$ (95% CI 0.72–1.34) on the 1–7 scale (Figure 2; Table 3).

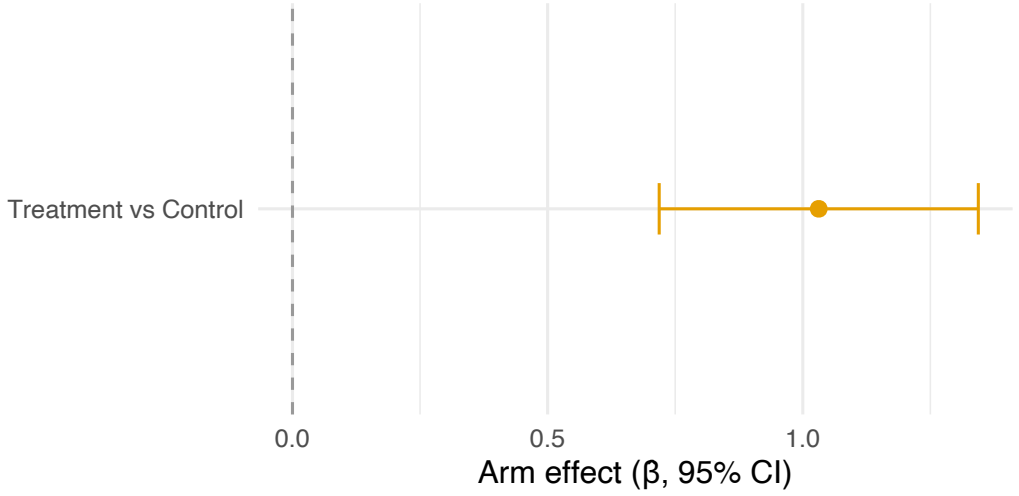

Figure 2

Table 3: Primary ANCOVA result (HC3 robust SEs).

Term	Estimate	95% CI	p-value
Arm (Tx–Ctl)	1.03	0.72 to 1.34	<0.001

4.4 Descriptive Outcomes

Control group participants were essentially unchanged in their vaccination intent before and after the intervention ($\Delta \approx +0.03$), while Treatment group participants increased by a bit more than a full point on average ($\Delta \approx +1.07$).

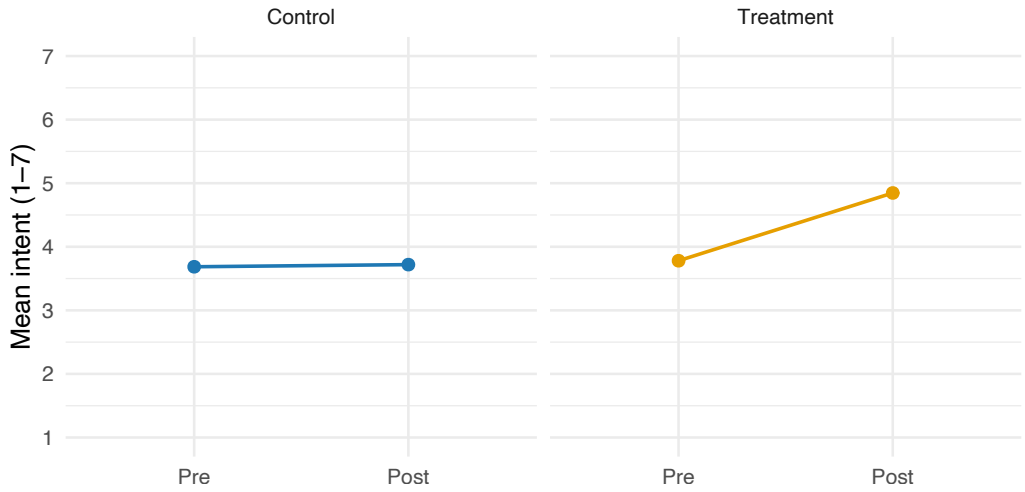

Figure 3

4.5 Distribution of Intention Changes

4.6 Responder Rates

Nearly two-thirds of Treatment participants (58 / 91, 63.7%) increased their vaccination intention by at least one point ($\Delta \geq 1$) versus about one in ten in Control (11 / 89, 12.4%).

4.7 Sensitivity Analyses

RIN-transform estimates were consistent in direction/inference with the primary model; excluding two borderline low-quality cases did not materially change results. Details are available in the public analysis notebook.

4.8 Durability (Exploratory)

An initial cohort of 90 participants who were inadvertently not presented with a post-intervention intent question after the intervention were re-contacted via Prolific. Sixty-six of them responded to the follow-up survey and provided delayed post-intervention intent data.

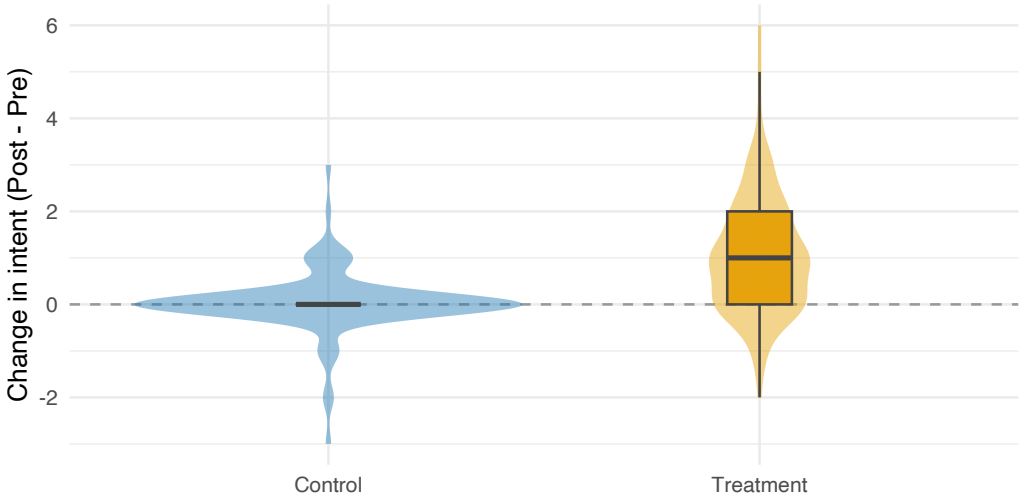

Figure 4

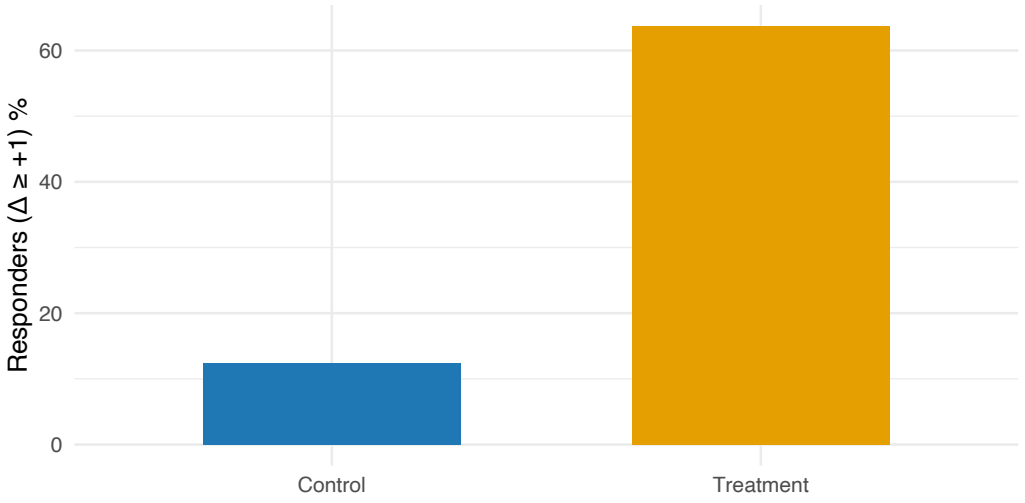

Figure 5

The median delay was ~2 days (range ≈ 0.3–7.1 days). The results were consistent with the confirmatory data set. Adjusted Treatment–Control difference: β ≈ 1.09 (95% CI 0.52–1.66; N = 66). Slicing the sample into three equal-sized delay windows, the effect appears consistent across all three: ~+1.01 for the shortest window (≤1.6 days), +0.94 for 1.6–2.1 days, and +1.59 for >2.1 days.

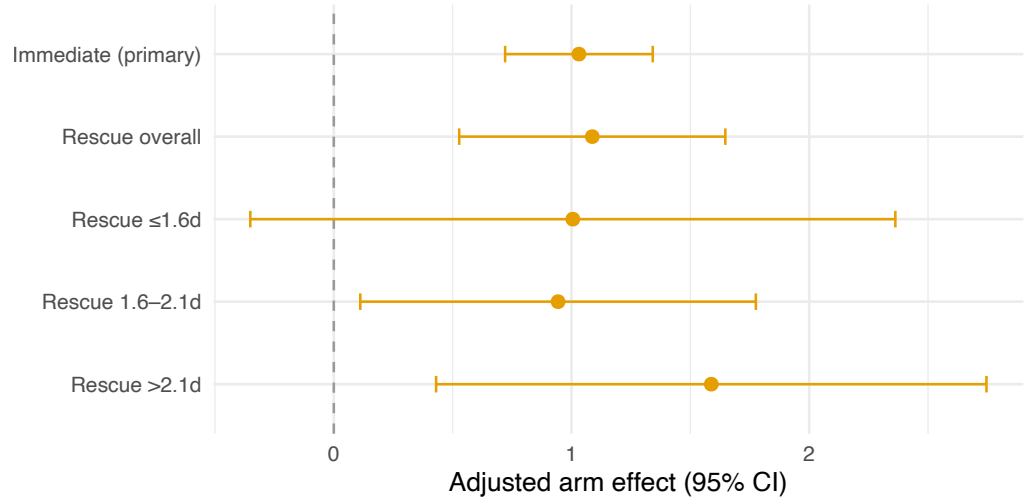

Figure 6

5 Discussion

In this preregistered two-arm online randomized trial with vaccine-hesitant U.S. parents of young children, an intervention framed around a mock appointment combining a review of factual MMR materials with a short motivational-interviewing-style LLM conversation produced a clear increase in vaccination intention relative to an active, non-vaccine control. The estimated adjusted arm effect was approximately one point on a seven-point intention scale, with exploratory follow-up in a separate cohort suggesting that gains persisted over several days.

5.1 Relation to prior work on vaccine communication

These findings align with a broader literature showing that respectful, autonomy-affirming conversations can shift parental vaccine attitudes and intentions. Motivational interviewing (MI) approaches delivered by clinicians have shifted postpartum mothers' intentions and in some contexts downstream vaccination rates, though effects vary by setting and intervention design (9–13). Recently, a cluster RCT in pediatric clinics that incorporated presumptive recommendations plus MI reported mixed, context-dependent effects on on-time immunization—benefits in one state but no overall difference across sites, underscoring that delivery setting, details, and target population matter (14).

Our contribution is to test a lightweight, pre-visit digital workflow that couples concise static materials with an adaptive motivational-interviewing-style conversation. The effect we observe is larger than many purely informational interventions targeting hesitant parents (15), consistent with the intuition that combining clear and vivid risk communication (e.g., anticipated regret, social norms, visual risk comparisons) with empathic, two-way dialogue is more persuasive than either mode alone.

5.2 Conversational AI for vaccine decisions

Evidence on chatbots and LLM-based agents for vaccination is accumulating. Multisite and national RCTs report mixed effects on COVID-19 vaccine confidence and intention (3,4), while a recent cluster RCT with parents found that a bespoke AI chatbot increased HPV vaccination uptake in middle-school girls (5). Furthermore, MI-oriented AI assistants have shown improvements in adult vaccine attitudes in randomized evaluation (6,7).

Beyond vaccines, randomized and quasi-experimental studies suggest that LLM-driven conversational agents can influence health decisions and self-management behaviors, though safety, drift, and alignment remain active concerns (16–20). And in adjacent domains, personalized, evidence-based dialogues with an AI have been shown to produce substantial and durable reductions in conspiracy beliefs (21), suggesting that tailored conversations can shift even entrenched attitudes.

Our study is novel in several respects. First, we targeted an imagined pivotal moment shortly before a due MMR dose. Second, we enforced brief but meaningful engagement (timer-gated carousel plus a short chat), trading depth for reach and practicality. Third, we used an active control that matched time-on-task and interactivity without vaccine content, strengthening internal validity. To our knowledge, this is the first randomized trial focused on MMR-hesitant parents to test the combination of timer-gated content review with MI-style LLM conversation against a structurally matched active control.

5.3 Interpreting effect size and mechanism

The adjusted between-arm difference (~1.03 on a 1–7 scale) is sizable in practical terms, with a substantial proportion of participants responding (63.7% of treatment participants increased intent by at least one point). On the adjusted scale, the effect size is roughly a standard deviation ($d \approx 0.98$). We characterize the effect as large, while noting the key caveat that the endpoint is intention rather than verified vaccination.

Mechanistically, the combination of (a) concise, vivid risk communication including "anticipated regret" elements and (b) empathic, autonomy-affirming MI-style dialogue is a plausible driver. Our two-stage screening enriched for parents who were not already certain to vaccinate, providing headroom for change.

5.4 Limitations

The study has several limitations. Most importantly, (i) Outcomes are self-reported intentions rather than verified vaccinations; intention–behavior gaps are common. Other limitations include: (ii) Participants were aware of topic content; blinding was infeasible for a content-based intervention, so demand/expectancy effects cannot be fully excluded. (iii) The exploratory durability analysis used delayed outcomes with attrition; while estimates were consistent with the confirmatory data set, caution is warranted in the interpretation of this finding. (iv) External validity to other populations (e.g., non-parents, non-U.S.) was not assessed; by design, we focused on MMR-hesitant U.S. parents of young children.

5.5 Implications and next steps

The results motivate a clear pathway for further research: a randomized clinical trial integrating parent-facing review of factual materials and motivational-interviewing-style conversation into a pre-appointment pediatric workflow, with EHR-confirmed vaccination as the primary endpoint. Given mixed results of clinician-only communication strategies in busy visits (14), pre-visit digital preparation that also provides clinicians a conversation summary merits testing.

6 Conclusion

A brief, appointment-framed MMR content review plus an MI-style LLM conversation significantly increased vaccination intention versus a non-vaccine active control, with encouraging signs of short-term durability.

7 Funding

No external funding.

8 Competing Interests

The author declares no competing interests.

9 Data & Code Availability

De-identified, participant-level data include hashed Prolific IDs and cannot be posted publicly. Upon reasonable request and a data-use agreement, we will share an analysis-ready table containing arm assignment, baseline/post outcomes, non-identifying covariates, and a data dictionary.

The full analysis (Quarto notebook, figures, and scripts) is public at https://sjforman.me/mmr-2-analysis/index.html. A machine-readable version of the analytic output is public at https://sjforman.me/mmr-2-analysis/analysis.md.

Access requests should be sent to the corresponding author and will be evaluated for academic/noncommercial use; approved requests will receive a secure link within 14 days.

10 Disclaimer

This preprint reports new research that has not been certified by peer review and should not be used to guide clinical practice.

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