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Research Article

Alternative science against the corrupt elites? The effects of pseudoscience and censorship accusations in health misinformation

Due to extensive regulations, pseudoscience and accusations of censorship are increasingly used as persuasive strategies in health misinformation. How effective are these? This experiment examines the effects of pseudoscientific misinformation about COVID-19 vaccines and genetically modified organisms (GMOs) by accounting for the rhetoric of the "persecuted hero narrative" (Baker, 2022), which involves accusations of censorship against media, platforms, and governments. The effects were generally limited: pseudoscientific content increased the perceived credibility of misinformation and heightened risk perceptions. The censorship accusation reduced the credibility of misinformation. We discuss the implications for understanding and countering such sophisticated health misinformation.

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Research questions

- Do science-appropriating techniques (e.g., pseudostatistical content) shape (message) credibility assessments as well as risk perception and behavioral intentions toward vaccine and GMO misinformation?
- Do censorship accusations affect credibility assessments, risk perceptions, and behavioral intentions?
- Does subjective numeracy (one's confidence about their numerical skills) condition one's receptivity/vulnerability to pseudoscientific content?
- Does scientific populism (antagonism against scientists) condition one's receptivity/vulnerability to censorship accusations?

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Essay summary

- Health misinformation increasingly incorporates scientifically looking details and accusations of censorship, yet little is known about how these features shape public responses.
- We conducted an experiment with *N* = 900 adult Singaporeans in 2024 using a (2 × 2 × 2) + 1 mixed-factorial design that crossed pseudoscientific content, censorship accusations, and topic (vaccine vs. GMOs), and had an unrelated control condition.
- Pseudoscientific content boosted the credibility of misinformation, increased GMO risk perceptions, and reduced use intentions, although the effects were small.
- Higher subjective numeracy increased vulnerability to pseudoscientific content, but this was contingent on the presence of censorship accusations.
- Among individuals high in scientific populism, pseudoscientific content combined with censorship accusations was associated with lower vaccination and GMO consumption intentions. However, not all of these interactive effects persisted in various robustness checks, so the findings on moderation by individual differences should be treated as provisional/suggestive evidence rather than conclusive.

Implications

Effects of pseudoscientific content

Misinformation that co-opts science could be particularly effective. Developments like preprint exposure and "I do my own research" movements (Chinn & Hasell, 2023; Vranic et al., 2022) increasingly normalize scientific-looking, unvetted information (Lee et al., 2021; Berg, 2025). Health blogs (e.g., on Substack) exploit this by circulating misleading "findings" based on unwarranted assumptions and statistical misrepresentations. Pseudoscience can involve fabricated statistics, misleading interpretations of real data, and substantive deviations from scientific procedures and norms (Hansson, 2025; Kuru, 2026a; Appendix A). In the near future, AI-generated hallucinated citations (i.e., non-existent research) may exacerbate pseudoscientific health misinformation (cf. Guo et al., 2025; Shao, 2025).

We focused on one specific form of pseudoscientific content within the broader domain of health misinformation. Health misinformation is conceptualized as a health-related claim based on anecdotal evidence or as a claim that is otherwise false or misleading because it lacks adequate scientific support (Suarez-Lledo & Alvarez-Galvez, 2021). Pseudoscience involves the imitation or appropriation of scientific features and can take multiple forms in the context of misinformation (Hansson, 2025; Kuru, 2026a).

We tested whether pseudoscientific content strengthens misinformation's effects. Research shows that scientific details increase credibility (Fang, 2024; HŠmmerli et al., 2025; Jonas et al., 2024). Yet, misinformation research has relied on abstract constructs such as "scientific-sounding bullshit" (Evans et al., 2020, p. 401; Pennycook & Rand, 2020, p. 188) and less realistic examples, such as the fictional "Valza virus" (O'Brien et al., 2021). While these studies provide important evidence, pseudoscientific health misinformation can be conceptualized more realistically as an integrated rhetorical package that combines a formal tone, structured reasoning, and statistical claims that co-occur to simulate and project scientific legitimacy onto real issues.

Our manipulation operationalized these features as an integrated rhetorical package in which a false health claim employed a formal tone, structured reasoning, fabricated statistics, and a wrongful causal interpretation. Accordingly, the estimates identify the effect of exposure to this bundled treatment of pseudoscientific health misinformation. They do not represent the effects of other forms of pseudoscience (e.g., fake experts) or other forms of (non-pseudoscientific) health misinformation at large. They cannot identify the independent contribution of any single component of the rhetorical package.

We found that pseudoscience slightly increased believability, and behavioral impacts were limited and topic-specific, shifting risk perceptions and intentions only for the GMO issue. This suggests that while pseudoscience influences attitudinal evaluation, the behavioral repercussions are more conditional. Risk perception and behavioral intentions shifted only for GMOs, further suggesting that the persuasive threat of pseudoscience is issue-contingent rather than uniform. There are several plausible explanations for this, including Singapore's high level of public trust in institutions (Appendix G).

Our findings do not diminish the need for vigilance: small and conditional effects may accumulate over time and contexts (cf. Udry & Barber, 2024). Other recent work also suggests that scientific authority or source cues (e.g., referencing a study in a post's title, as in "according to the CDC…") result in higher rates of sharing or retweets of misinformation on X (formerly Twitter) (Harrando et al., 2026). Collectively, these findings highlight the value of fostering skills for critically processing numerical information to counter such effects of pseudoscience. Platforms may provide accessible, engaging information (e.g., https://www.covid-datascience.com/) (Morris, 2025a, 2025b). Rather than relying on debunking approaches, people may be pre-emptively trained against statistical misinformation to bolster the impact of such supply-side initiatives (Kuru, 2025, 2026b). Practitioners may integrate literacy campaigns to target both the recognition of fabricated data, fake or unvetted experts, and the identification of misleading causal interpretations in epidemiological datasets. The public can be trained to distinguish observational vs. causal epidemiological evidence (e.g., the Vaccine Adverse Event Reporting System [VAERS]; see Kuru, 2025; Morris, 2025b).

Effects of censorship accusations

This study also provides the first evidence on the effects of accusations of censorship in misinformation messages. Investigating this rhetorical strategy is important given its increasing prevalence and politicized use. For instance, U.S. President Donald Trump issued an executive order targeting the travel visas for disinformation researchers, accusing them of "censorship" (Luscombe, 2025). Content analysis of X (formerly *Twitter*) showed that retractions of miscontextualized research have been labeled as censorship (Abhari & Horvát, 2025)**.** Censorship accusations regarding health misinformation regulation have gained extensive attention in Singapore, too, especially on messaging applications such as anti-vaccine Telegram channels (e.g., "Healing the Divide") (Cheng, 2021). On less-regulated platforms, accusations of censorship constitute an important aspect of the "persecuted hero narrative," framing dissenting actors as truth-tellers suppressed by powerful elites (Baker, 2022). Drawing on evidence that people identify more with conspiracy theorists who claim to be victims of discrimination (Nera et al., 2022), we expected that censorship claims could bolster the effects of misinformation.

Contrary to our expectations, accusations of censorship reduced the credibility of misinformation. People may not have found the underdog or victimization narrative convincing (cf. Nera et al., 2022), or censorship framing may have primed associations with stigma around misinformation. This indicates that *the persecuted hero's* accusation of censorship, common on less-regulated platforms like health blogs (Baker, 2022), may be off-putting to the wider population while resonating only with devoted followers within those more niche platforms. Results provide insights into the potential effects of rhetorical attacks amid the loosening of misinformation regulations. As our manipulation combined the narrative content of censorship accusations with its typical stylistic features (e.g., capitalization, exclamation marks) to mimic the heated language commonly used, future research may disentangle the independent contributions of each component. While our study provides evidence from Singapore, a relatively understudied high-trust and regulated media environment (Ronzani, 2025), accusations of censorship may operate differently in more polarized contexts such as the United States, Brazil, and Turkey. Censorship accusations may instead enhance the credibility of misinformation among individuals already predisposed to distrust institutions (see Bowyer & Kahne, 2019; Ecker et al., 2022). Yet, recent work shows that highly emotive misinformation can "backfire" and reduce perceived credibility even in polarized contexts such as the United States (Phillips et al., 2025), underlining the need for more research.

Effects of individual differences

Subjective Numeracy (SN hereafter): Individuals with higher SN (i.e., greater confidence in numerical ability) were more influenced by pseudoscientific content, leading to higher COVID-19 vaccine risk assessments. This suggests that high SN levels can be a vulnerability when encountering pseudoscience. Literacy interventions may highlight that one's subjective sense of competence in numerical skills should not be an asset against misinformation on its own (see Appendix C, Part 5). Interactive or gamified quizzes can provide a range of challenging numeracy questions to counter overconfidence. Methodologically, while an SN scale has been offered as an alternative to objective numeracy measures (Fagerlin et al., 2007), we recommend against using it in place of objective numeracy in misinformation research; this is not a blanket call to avoid using the SN scale. We also measured objective numeracy (not pre-registered), but it had low reliability (Appendix C, Part 2; cf. Nan et al., 2022; Peters et al., 2006). The SN three-way interaction for vaccine risk perception remained significant after Benjamini–Hochberg false discovery rate (BH-FDR) adjustment (q = .034; see Appendix B, Part 3).

Scientific Populism (SP hereafter): We examined whether SP—a belief that scientific knowledge production is controlled by self-serving elites who suppress dissenting voices (Lerner et al., 2025; Mede et al., 2022; Mede & Schäfer, 2020)—conditions the effects of accusations of censorship. In the absence of accusations of censorship, the effects were inconsistent under pseudoscience conditions; individuals high in SP had higher vaccination intentions but lower GMO consumption intentions (for discussion, see Appendix G). However, the combination of pseudoscientific content and accusations of censorship was associated with lower behavioral intentions to vaccinate and consume GMOs among individuals high in SP. These findings extend our understanding of SP (Lerner et al., 2025; Mede et al., 2022; Mede & Schäfer, 2020). For individuals high in SP, accusations of censorship may function as identity signaling/validation (cf. Kuo & Marwick, 2021), reframing pseudoscientific evidence as "suppressed truths" that align with anti-establishment worldviews. This highlights the importance of interventions that approach high-SP individuals via nonconfrontational strategies, such as peer and crowdsourced fact-checking and norm-based messaging, rather than confrontational ones like debunking or those involving institutional authorities directly (Panizza et al., 2023; Pasquetto et al., 2022). After the BH-FDR adjustment, the SP three-way interaction remained significant for vaccination intention (q = .034) but not for GMO consumption intention (q = .069; see Appendix B, Part 3).

Both of these individual difference moderators (SN and SP) offer a theoretically relevant test and only provisional evidence for the conditional effects of pseudoscience and censorship manipulations; hence, future research should implement high-powered (larger sample size) tests for more conclusive evidence.

Findings

Finding 1: Pseudoscientific content boosted message credibility (vaccine and GMO misinformation), but this effect was limited when paired with accusations of censorship.

For the perceived credibility outcome, data were pooled across the vaccine and GMO contexts to examine the overall effects of pseudoscientific content and censorship (see Appendix C, Part 1 for justifications). We first conducted a one-way ANOVA on the five groups (control and experimental arms), which indicated an overall significant difference in credibility judgments, F (4, 895) = 8.83, p < .001, partial η^2 = .04.

Experimental conditions were then entered as predictors with the control as reference; Tukey's HSD was used for pairwise comparisons. As the control condition involved an unrelated topic, the comparisons reflect exposure to health misinformation and its four variations (two theoretical manipulations).

There was a significant difference between No-Pseudo/No-Censorship and the control (M_{diff} = -0.10, *p* = .005, Cohen's *d* = -0.45); and there was a significant difference between No-Pseudo/Censorship and the control (M_{diff} = -0.13, *p* < .001, Cohen's *d* = -0.54). In contrast, Pseudo/No-Censorship did not differ significantly from Control (M_{diff} = -0.01, *p* = .998, Cohen's *d* = -0.04), suggesting that the pseudoscientific condition left credibility comparable to that of non-misinformation content, in contrast to the non-pseudoscientific condition.

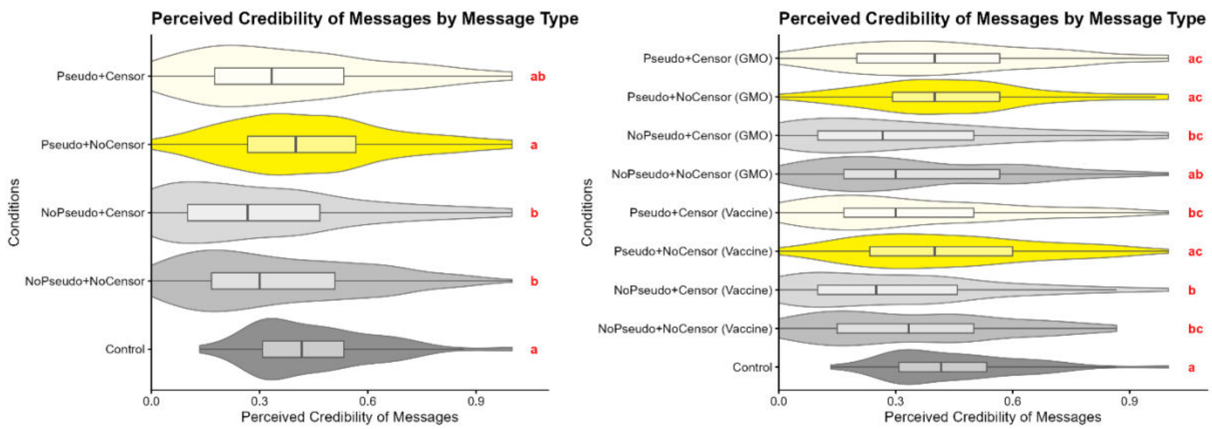

Figure 1. Perceived credibility of misinformation across experimental conditions. *Each color represents one experimental condition: Control, No-Pseudo/No-Censorship, No-Pseudo/Censorship, Pseudo/No-Censorship, and Pseudo/Censorship. The left panel presents the combined results across vaccine and GMO topics. The right panel unpacks the results separately by topic (vaccine and GMO). Conditions sharing a common letter are not significantly different (p > .05), while those with distinct letters differ significantly (p < .05).*

This pattern, however, diminished when pseudoscientific content was paired with a censorship accusation. The Pseudo/Censorship condition did not differ significantly from No-Pseudo/No-Censorship (M_{diff} = 0.03, *p* = .71, Cohen's *d = 0.12*), while the Pseudo/No-Censorship condition significantly differed from No-Pseudo/No-Censorship (M_{diff} = 0.09, *p* = .002, Cohen's *d* = 0.38). These results indicate that accusations of censorship may undermine the credibility-boosting effect of pseudoscientific content.

Importantly, there was also a significant difference between Pseudo/No-Censorship and No-Pseudo/Censorship (M_{diff} = 0.12, *p* < .001, Cohen's *d* = 0.48). Effects are visualized in Figure 1 (left), with issue-level analyses (Figure 1, right) indicating that credibility differences were largely driven by the vaccine context. Factorial analyses excluding the control yielded consistent findings (Appendix F).

Finding 2: Pseudoscientific content increased GMO risk perceptions, but reduced willingness to consume GMOs only when the censorship accusation was absent.

For risk and intention outcomes, the issues are tested separately due to their distinct nature and issue-specific question wording. The one-way ANOVA results revealed significant differences in GMO risk perceptions across the five conditions, *F* (4, 498) = 4.26, *p* = .002, partial η^2 = .03. Tukey's HSD pairwise comparisons showed that both pseudoscientific conditions elevated GMO risk perceptions relative to control: Pseudo/No-Censorship (M_{diff} = 0.15, *p* = .001, Cohen's *d* = 0.57) and Pseudo/Censorship (M_{diff} = 0.12, *p* = .022, Cohen's *d* = 0.45; Figure 2, bottom-left).

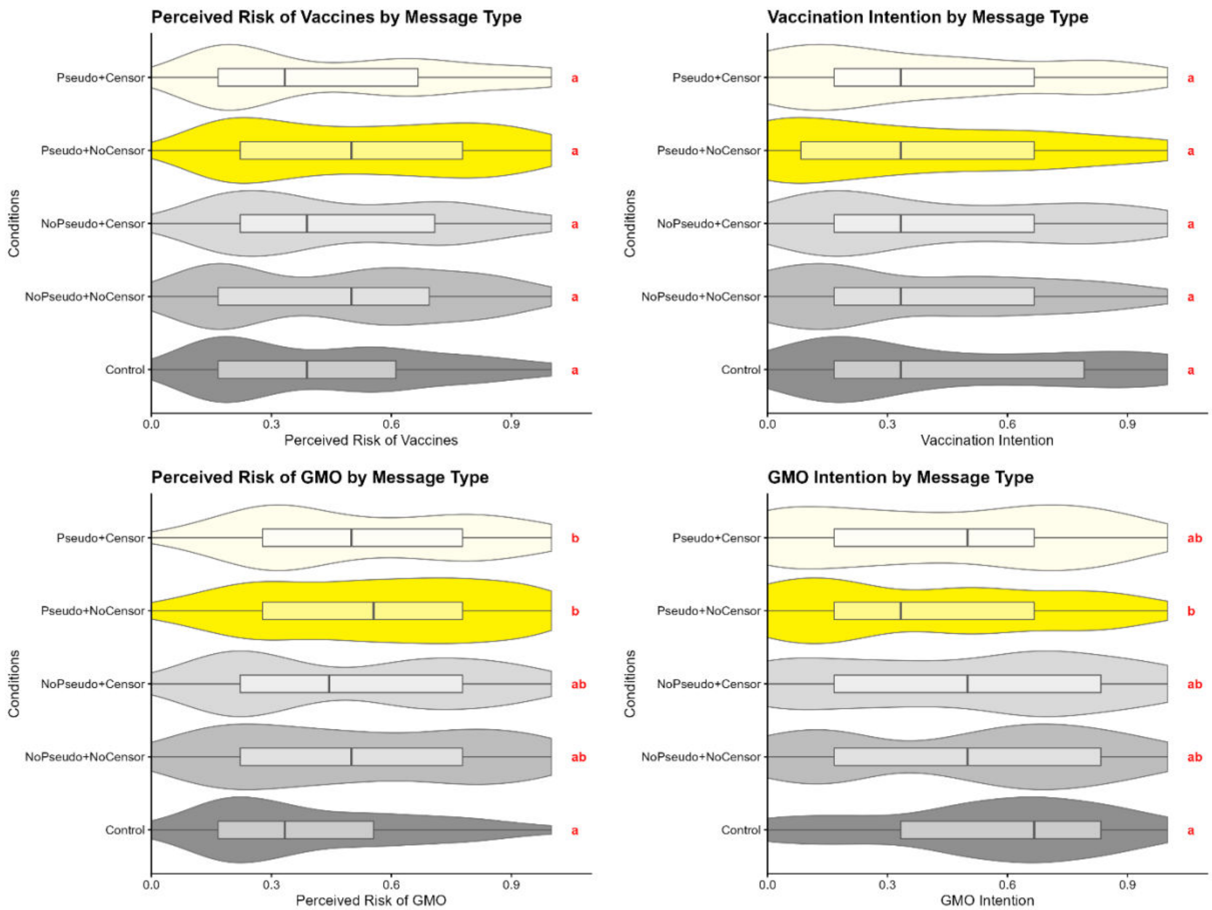

Figure 2. Perceived risk and intentions. *Each color represents one experimental condition: Control, No-Pseudo/No-Censorship, No-Pseudo/Censorship, Pseudo/No-Censorship, and Pseudo/Censorship. Conditions sharing a common letter are not significantly different ($p > .05$), while those with distinct letters differ significantly ($p < .05$).*

Regarding behavioral intentions, the one-way ANOVA results also showed a significant main effect, F (4, 498) = 3.23, p = .012, partial η^2 = .03. Regression showed that the Pseudo/No-Censorship condition was the sole message type that significantly reduced GMO consumption intentions compared to the Control group (M_{diff} = -0.15, p = .006*,* Cohen's d = -0.50; Figure 2, bottom-right). All other conditions (p > .60) did not differ significantly from the Control group. We did the same further analysis reported in Finding 1 for these outcome variables as well (Appendix F).

Finding 3: Among individuals with higher levels of SN, exposure to pseudoscientific content without accusations of censorship was associated with higher perceived vaccine risk.

For moderation by individual differences, we relied on the same regression approach (Appendix C, Part 4 provides alternative tests, including the control). A three-way interaction analysis revealed that SN moderated the relationship between the pseudoscientific content and vaccine risk perceptions, contingent on the presence of censorship (b = -0.66, p = .013; adjusted R^2 = .02). As shown in Figure 3 (left), without censorship, pseudoscientific misinformation increased vaccine risk perceptions among participants with high SN. This pattern seemed to reverse in the Pseudo/Censorship condition (Figure 3, right), where high SN predicted lower risk perceptions. The accusation of censorship thus neutralized the pseudoscience effect on individuals with high SN. This interaction remained significant after BH-FDR adjustment, although its small effect size and limited power warrant cautious interpretation (see Appendix B, Parts 2 and 3 for details and the other correction method of Bonferroni).

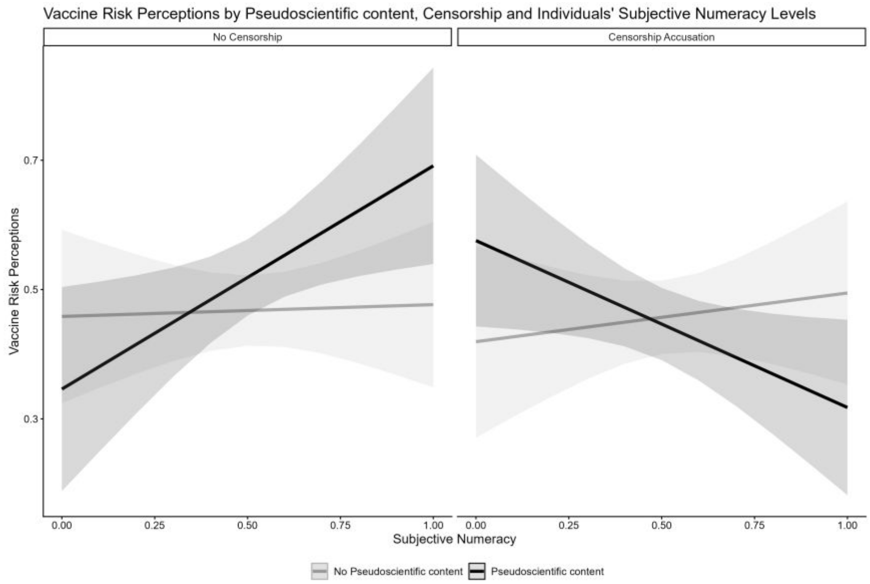

Figure 3. Three-way interaction on vaccine risk perception: the moderating role of SN. *The left panel displays predicted vaccine risk perceptions as a function of SN (x-axis) and pseudoscientific content (non-pseudoscientific vs. pseudoscientific; line color) in the absence of a censorship accusation. The right panel displays the same relationships when a censorship accusation is present. Shaded areas represent 95% confidence intervals. Higher SN amplified pseudoscientific persuasion on vaccine risk perceptions, but this effect appeared to reverse when censorship accusations were present.*

Finding 4: Among people with a higher level of SP*, combining pseudoscientific content with censorship accusations is associated with lower intentions to vaccinate and lower willingness to consume GMO (higher intentional avoidance of consuming GMO).*

Regressions showed a three-way interaction among pseudoscientific content, censorship accusations, and SP for both vaccination intention (b = −0.98, p = .008) and GMO consumption intention (b = 0.89, p = .009; adjusted R^2 = *.01* and *.05,* respectively). Across both topics, the influence of pseudoscientific misinformation depended jointly on the presence of censorship cues and individuals' SP. The corresponding conditional patterns are described below. The vaccination-intention interaction remained significant after BH-FDR adjustment, whereas the GMO consumption-intention interaction did not and should therefore be considered only provisional (Appendix B, Parts 2 and 3, also see the other correction method of Bonferroni).

In the absence of accusations of censorship, individuals high in SP had higher vaccination intentions when exposed to pseudoscientific misinformation (vs. non-pseudoscientific misinformation; Figure 4, left). This pattern reversed when accusations of censorship were present (Figure 4, right); high SP then predicted lower vaccination intentions.

For GMO-related intentions, the pattern seemed to differ. Without censorship, high SP was associated with lower intentions to consume GMOs in the presence of pseudoscientific content (Figure 5, left), the opposite of the vaccine finding. When accusations of censorship accompanied pseudoscientific misinformation (Figure 5, right), high SP again predicted lower intentions to use GMOs. The divergent results observed between the left panels of Figure 4 and Figure 5 may indicate issue-based differences. They may be attributable to the empirical context at the time of data collection, underscoring the importance of conceptual replication by testing these effects across diverse issues (see Appendix G, Part

2, for further discussion). Yet, we caution that the three-way interaction for GMOs was not robust to additional tests and hence is relatively more provisional than the vaccine-intentions-related interaction. Table 1 summarizes the specific effects tested, the corresponding analytical approaches, and the findings.

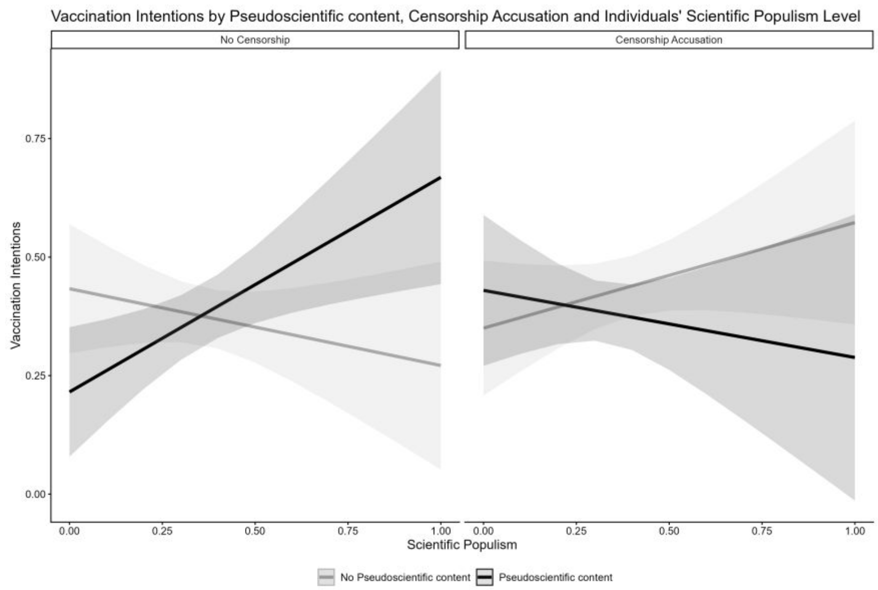

Figure 4. Three-way interactions on vaccination intention: the moderating role of SP. *The left panel displays predicted vaccination intentions as a function of SP and pseudoscientific content in the absence of a censorship accusation. The right panel displays the same relationships when a censorship accusation was present. Among individuals high in SP, pseudoscientific content alone boosted vaccination intentions, but this reversed when censorship accusations were present.*

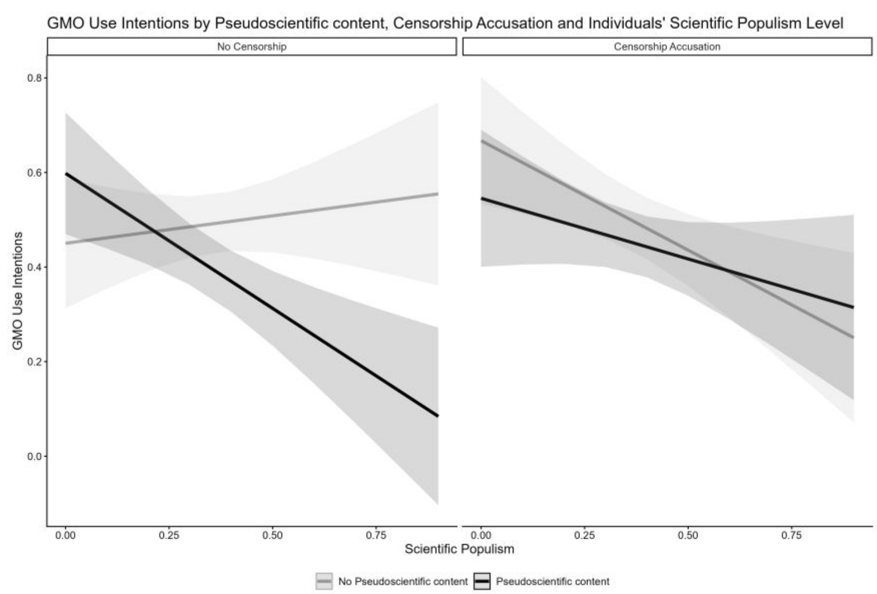

Figure 5. Three-way interactions on GMO intention: the moderating role of SP. *The left panel displays predicted GMO consumption intentions as a function of SP and pseudoscientific content in the absence of a censorship accusation. The right panel displays the same relationships when a censorship accusation was present. Among individuals high in SP, pseudoscientific content was associated with lower intentions to consume GMOs, whether a censorship accusation was present or not.*

Table 1. *Summary of specific effects tested, analytical approaches, and the findings.*

Focus	DV(s)	Conditions	Primary analysis	Primary finding
Pseudo-scientific-content effects	Credibility	Five groups including control, topics pooled (C1; C2+C6, C3+C7, C4+C8, and C5+C9)	One-way ANOVA + Tukey contrasts	Pseudo/No-Censorship produced higher credibility than non-pseudoscientific conditions. Results are largely driven by the vaccine issue.
	GMO risk perception	Five groups including GMOs and control (C1, C6–C9)	One-way ANOVA + Tukey contrasts	Compared with control, both pseudoscientific message conditions showed higher GMO risk perceptions.
	GMO consumption intention	Five groups including GMOs and control (C1, C6–C9)	One-way ANOVA + Tukey contrasts	Pseudo/No-Censorship reduced consumption intention relative to control.
	Vaccine risk perception and vaccination intention	Five groups including vaccine and control (C1–C5)	One-way ANOVA + Tukey contrasts	No significant group differences were detected.
Censorship-accusation effects	Credibility	Five groups, including control, topics pooled (C1; C2+C6, C3+C7, C4+C8, and C5+C9)	One-way ANOVA + Tukey contrasts	Censorship accusations did not increase credibility; the pseudoscience advantage appeared smaller when censorship accusations were present.
	Vaccine risk perception, vaccination intention, GMO risk perception, and GMO consumption intention	Five groups, including control, topic-specific groups (vaccine: C1–C5; GMO: C1, C6–C9)	One-way ANOVA + Tukey contrasts	No consistent evidence indicated that censorship accusations increased persuasion.
Subjective-numeracy moderation	Vaccine risk perception	Four vaccine groups (C2–C5)	Three-way OLS	Among participants higher in SN, pseudoscientific content was associated with higher vaccine risk without censorship, but not when censorship was present.
	Perceived credibility, vaccination intention, GMO	Four groups (for credibility: C2+C6, C3+C7, C4+C8, C5+C9; for vaccine:	Three-way OLS	No corresponding three-way interactions were detected.

Focus	DV(s)	Conditions	Primary analysis	Primary finding
	risk perception, and GMO consumption intention	C2–C5; for GMO: C6–C9)		
Scientific-populism moderation	Vaccination intention	Four vaccine groups (C2–C5)	Three-way OLS	Among participants higher in SP, pseudoscientific content was associated with higher intention without censorship but lower intention when censorship was present.
	GMO consumption intention	Four GMO groups (C6–C9)	Three-way OLS	Within the pseudoscientific-content conditions, high SP was associated with lower intentions to consume GMOs with or without censorship.
	Perceived credibility, vaccine risk perception, and GMO risk perception	Four groups (for credibility: C2+C6, C3+C7, C4+C8, C5+C9; for vaccine: C2–C5; for GMO: C6–C9)	Three-way OLS	No corresponding three-way interactions were detected.

Note: C denotes assigned condition: C1 = Control; C2 = No-Pseudo/No-Censorship Vaccine; C3 = No-Pseudo/Censorship Vaccine; C4 = Pseudo/No-Censorship Vaccine; C5 = Pseudo/Censorship Vaccine; C6 = No-Pseudo/No-Censorship GMO; C7 = No-Pseudo/Censorship GMO; C8 = Pseudo/No-Censorship GMO; and C9 = Pseudo/Censorship GMO. For credibility analyses, corresponding vaccine and GMO conditions were pooled across topics (C2+C6, C3+C7, C4+C8, and C5+C9). Five-group analyses included C1, whereas three-way moderation models excluded C1. OLS = ordinary least squares.

Methods

We conducted a cross-sectional survey-experiment in January 2024 in Singapore, using an online non-probability sample with demographic quotas collected by Qualtrics (N = 900). Random assignment was successful (Appendix A and B for sample and power analysis).

Manipulations

After consent and pledge, participants completed pre-test questions, the experiment, outcome measures, manipulation checks, and debriefing. The experiment was a mixed factorial design with eight experimental conditions and one control condition:

Pseudoscientific content: Non-pseudoscientific content (N = 405) vs. pseudoscientific content (N = 389). Non-pseudoscientific misinformation made inaccurate claims in plain language without supporting evidence. In contrast, pseudoscientific misinformation adopted a scientific-appearing format, incorporating a more formal tone, structured argumentation, fabricated statistics with wrongful causal interpretation, and a statistical results table. These multiple elements collectively constitute pseudo-scientific manipulation as a package. This approach provides strong ecological validity (a scientific tone in the absence of statistics, or a non-scientific tone in the presence of statistics, is less plausible), though it precludes conclusions about which individual feature drives the observed effects; future research may disentangle or "unbundle" these features' independent contributions without being too reductionist.

Censorship accusation: The absence (*N* = 403) vs. presence (*N* = 391) of censorship accusation. Conditions with a censorship accusation had one additional paragraph at the end, claiming that these facts are censored by the media and big pharma, and, mirroring the heated language in real-world examples, they included explicit mentions of censorship in capital letters and exclamation marks (Appendix D).

Issues (conceptual replication): COVID-19 vaccines (*N* = 397) and GMOs (*N* = 397).

Control condition was an unrelated topic (*N* = 106) with a reading task on baseball rules, including numerical details. Baseball, as a niche sport in Singapore, presents a level of task difficulty comparable to that observed in the experimental conditions. This provides a comparative benchmark for outcome variables, particularly for issue-specific outcomes (Guay et al., 2023; see Appendix C, Part 1, for the rationale for the unrelated Control condition). An unrelated control also serves as a benchmark against the full factorial structure of experimental conditions. Future research can test controls on similar topics to more conservatively isolate the effects.

Outcome variables

Table 2 presents the descriptive statistics. All multi-item scales were averaged into indices from 0 to 1, with higher scores indicating greater levels of the construct. For behavioral intentions, the GMO item was reverse-coded to have consistent directionality with the vaccine measure. Behavioral intentions were measured using single-item indicators, which may be less reliable than multi-item measures. However, in the vaccine literature, single-item measures are primarily used (Fishman et al., 2024). For risk perceptions, we also measured post-test levels and post–pre-test difference scores (Appendix C, Part 3).

Table 2. *Measures, reliability, and descriptive statistics.*

Variable	Items	Response scale	Reliability	M (SD)
Perceived credibility (adapted from (Albarracín et al., 2024)	5 items; example: "How accurate do you find the information you just read?"	7-point: "Not at all accurate" to "Extremely accurate"	α = .94	.38 (.24)
Risk perceptions	3 items; example: "How risky do you think [side effects of COVID-19 vaccines are / eating GMO is]?"	7-point: "Not at all risky" to "Extremely risky"	α = .94	Vax: .46 (.28) GMO: .49 (.29)
Behavioral intentions	"How likely are you to get a COVID-19 vaccine (or booster shot) in future if health authorities recommend it for your age group? / avoid buying GMO food?"	7-point: "Not at all likely" to "Extremely likely"	Single item	Vax: .40 (.32) GMO: .48 (.32)

Variable	Items	Response scale	Reliability	M (SD)
Subjective numeracy (adapted from Fagerlin et al., 2007)	8 items; example: “How good are you at figuring out how much a shirt will cost if it is 25% off?”	7-point: “Not at all good” to “Extremely good”	α = .91	.51 (.22)
Scientific populism (adapted from Mede et al., 2021)	8 items; example: “Scientists are in cahoots with politics and business”	7-point: “Not at all true” to “Extremely true”	α = .85	.36 (.18)

Note: We also measured objective numeracy (not pre-registered). See Appendix C for related analyses and other pre-registered tests.

Analysis

We first used one-way ANOVA to test overall differences among experimental conditions. When an omnibus test indicated overall differences, Tukey-adjusted pairwise contrasts were used to locate specific group differences while controlling the familywise Type I error rate within that outcome. We then used OLS regression to test moderation involving the experimental factors and continuous moderators, following recommendations for regression-based experimental designs with interactions (cf. Green & Aronow, 2011). The moderation models excluded the unrelated control because it was not a misinformation condition and therefore had no defined level of either message manipulation (e.g., absence vs. presence of censorship accusation). Alternative analyses including the control yielded broadly similar conclusions (Appendix C, Part 4). Based on reviewer and editorial feedback, we conducted additional robustness checks for multiple comparison adjustments. Benjamini-Hochberg false discovery rate adjustments (Benjamini & Hochberg, 1995) were applied separately to the three-way interaction tests within the credibility, vaccine-outcome, and GMO-outcome families (Appendix B, Part 3). Credibility was pooled across topics as a measure of general message believability and was also tested separately by issue. Risk perceptions and behavioral intentions were analyzed separately by topic because they represent more issue-specific outcomes and question wordings were issue-specific too. We conducted additional analyses treating 1) post-test minus pre-test difference scores and 2) post-test scores as outcomes by controlling for pre-test versions (Appendix C, Part 3). These analyses yielded similar conclusions.

Pre-registration at https://aspredicted.org/FJW_MCH. Data/code: Harvard Dataverse at https://doi.org/10.7910/DVN/OBTXXS. Generative Artificial Intelligence (AI) services were not used at any stage/component of this study. Grammarly was used for proofreading.

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O. K. designed the study, obtained funding, and collected the data. O. K. and S. Z. analyzed and wrote the paper and worked together on its submission and revisions. O. K. and S. Z. contributed equally; O.K. is the corresponding author (okuru@nus.edu.sg).

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Competing interests
The authors declare no competing interests.

Ethics
The research protocol employed was approved by the institutional review board of the National University of Singapore. Human subjects provided informed consent. Race/ethnicity (Chinese, Malay, Indian, Other), and sex (male, female, other) are reported, as defined by author who used existing measures used in the academic research in the country. These variables were not the central focus in the experimental study but were used to assess the demographic diversity of the sample.

Data availability
All materials needed to replicate this study are available via the Harvard Dataverse: https://doi.org/10.7910/DVN/OBTXXS

Appendix A: Sample, balanced checks, and manipulation tests

Part 1: Sample description

This is an online non-probability sample of adults (min. age 21). Quotas ensured demographic representations aligned with the population makeup. There were 2,070 survey attempts. 40 respondents who indicated they would not be fully honest with their respondents were removed before completing the survey; 413 respondents failed the first attention check; 158 respondents failed the second attention check; and 529 respondents did not complete the survey. In the end, there were 930 successful completes, but 11 of these withdrew consent after debriefing, resulting in 919 valid completes. Nineteen speeders (approximately the top 3% fastest, per the survey company's recommended threshold, which corresponds to those who completed the study under 7 minutes) were removed. We also identified eight laggards who spent more than 10 minutes on the manipulation message page, suggesting multitasking or inattention; however, because this justification was unclear given the slightly varying lengths of the manipulations, we did not exclude them from our reported analysis. The removal of these eight laggards did not change the results.

The average age was M = 42.1 years (SD = 13), and the median was 40. 51% were female; 77% were Chinese, 10% Malay, 6% Indian, and 7% other ethnicities. 9% of the sample had some high school education at most but no diploma, 18% had a high school diploma or some college but no college degree, 62% had college or equivalent degrees, while 11% had some type of graduate or professional degree. The median household monthly income was 7,001-9,000 SGD. These are comparable to the latest census information (Singapore Department of Statistics, 2025).

While non-probability samples yield experimental results similar to probability-based samples (Krupnikov et al., 2021), the findings cannot be directly generalized to the entire population.

Part 2: Balanced cells check

Table A1 shows our randomization and balanced cell results. Randomization worked successfully for most variables except for social media news exposure. But for our outcome variables, moderators, and demographic variables, no significant differences are observed.

Table A1. *Randomization check results.*

Variable	Test (F)	G1 (*N* = 106)	G2 (*N* = 107)	G3 (*N* = 98)	G4 (*N* = 91)	G5 (*N* = 101)	G6 (*N* = 105)	G7 (*N* = 95)	G8 (*N* = 100)	G9 (*N* = 97)
Age	1.823	0.37 (0.22)	0.38 (0.23)	0.40 (0.22)	0.33 (0.22)	0.42 (0.23)	0.33 (0.25)	0.38 (0.21)	0.35 (0.23)	0.37 (0.23)
Female	1.364	0.56 (0.50)	0.50 (0.50)	0.40 (0.49)	0.49 (0.50)	0.49 (0.50)	0.53 (0.50)	0.45 (0.50)	0.58 (0.50)	0.57 (0.50)
Chinese	0.858	0.78 (0.41)	0.83 (0.38)	0.83 (0.38)	0.75 (0.44)	0.73 (0.44)	0.78 (0.42)	0.75 (0.44)	0.74 (0.44)	0.73 (0.45)
Malay	0.849	0.11 (0.32)	0.07 (0.25)	0.07 (0.26)	0.10 (0.30)	0.14 (0.35)	0.08 (0.27)	0.13 (0.33)	0.12 (0.33)	0.13 (0.34)
Indian	0.286	0.07 (0.25)	0.05 (0.21)	0.04 (0.20)	0.07 (0.25)	0.05 (0.22)	0.07 (0.25)	0.05 (0.22)	0.08 (0.27)	0.05 (0.22)
Other race	0.398	0.04 (0.19)	0.06 (0.23)	0.06 (0.24)	0.09 (0.28)	0.08 (0.27)	0.08 (0.27)	0.07 (0.26)	0.06 (0.24)	0.08 (0.28)
Education	0.967	0.61 (0.25)	0.57 (0.23)	0.56 (0.27)	0.62 (0.24)	0.55 (0.28)	0.60 (0.25)	0.61 (0.25)	0.59 (0.26)	0.57 (0.24)
Income	1.167	0.33 (0.25)	0.40 (0.26)	0.42 (0.23)	0.36 (0.26)	0.36 (0.25)	0.40 (0.24)	0.41 (0.26)	0.37 (0.24)	0.37 (0.28)
Liberal	0.797	0.48 (0.21)	0.49 (0.20)	0.50 (0.19)	0.49 (0.21)	0.46 (0.18)	0.51 (0.22)	0.48 (0.21)	0.51 (0.21)	0.50 (0.17)
Pre-vax risk	1.123	0.38 (0.25)	0.36 (0.25)	0.40 (0.26)	0.41 (0.26)	0.33 (0.25)	0.33 (0.28)	0.39 (0.27)	0.37 (0.26)	0.40 (0.27)
Pre-GMO risk	1.487	0.38 (0.24)	0.39 (0.25)	0.40 (0.26)	0.39 (0.24)	0.41 (0.23)	0.35 (0.25)	0.45 (0.29)	0.36 (0.23)	0.40 (0.23)
Pre-AI risk	0.801	0.32 (0.21)	0.34 (0.23)	0.35 (0.26)	0.37 (0.26)	0.32 (0.22)	0.32 (0.22)	0.36 (0.25)	0.37 (0.26)	0.37 (0.25)
Populism	0.739	0.35 (0.16)	0.37 (0.18)	0.38 (0.19)	0.36 (0.20)	0.33 (0.14)	0.36 (0.18)	0.37 (0.20)	0.35 (0.20)	0.37 (0.18)
Subjective numeracy	0.271	0.52 (0.22)	0.51 (0.23)	0.51 (0.21)	0.51 (0.21)	0.49 (0.23)	0.51 (0.21)	0.53 (0.24)	0.52 (0.24)	0.49 (0.21)
Trust scientists	0.999	0.47 (0.19)	0.47 (0.17)	0.47 (0.20)	0.47 (0.22)	0.42 (0.19)	0.50 (0.21)	0.45 (0.25)	0.46 (0.20)	0.45 (0.19)
Trust science	0.722	0.53 (0.22)	0.53 (0.20)	0.50 (0.22)	0.51 (0.25)	0.47 (0.21)	0.51 (0.22)	0.51 (0.28)	0.51 (0.25)	0.49 (0.22)
NFC	1.037	0.49 (0.20)	0.46 (0.20)	0.50 (0.16)	0.45 (0.21)	0.46 (0.20)	0.50 (0.20)	0.48 (0.23)	0.48 (0.20)	0.45 (0.20)
Social news consume	2.221*	0.34 (0.25)	0.30 (0.25)	0.34 (0.22)	0.39 (0.28)	0.32 (0.24)	0.42 (0.25)	0.36 (0.27)	0.39 (0.26)	0.36 (0.23)
Objective numeracy	0.414	0.81 (0.24)	0.84 (0.21)	0.80 (0.22)	0.83 (0.22)	0.83 (0.21)	0.84 (0.22)	0.84 (0.22)	0.82 (0.25)	0.82 (0.24)

*Note: * denotes p < .05.*

Part 3: Manipulation tests

There were four sets of manipulation checks, assessing whether manipulations worked via diverse ways:

1. *Topic identification*

To verify the effectiveness of the topic manipulation, we employed multiple items. The first item included a fictitious distractor topic (History Museums), while the second item presented only the three target topics (GMOs, Vaccination, and Rules of Baseball [Control]). Participants in the eight experimental conditions successfully identified their assigned topics, with accuracy rates exceeding 92% across all groups (χ^2 = 1,377.23, p < .001; χ^2 = 1,350.86, p < .001).

Although the control conditions yielded more varied responses (accuracy rates of 22% and 66%), this pattern was expected given the control group's baseline nature. Crucially, regarding the control topic itself, participants in the control condition consistently demonstrated greater general knowledge of and interest in baseball compared to those in other conditions (Knowledge: F = 19.76, p < .001; Interest: F = 2.93, p < .001). Furthermore, on a binary-choice question about the assigned topic, accuracy rates exceeded 98% across all conditions, including controls. Collectively, these results indicate that the topic manipulation was successful.

2. *Pseudoscientific content manipulation*

To assess the effectiveness of the pseudoscientific content manipulation, participants were asked whether the messages contained statistics or numerical findings, tables, or figures, and to indicate their level of certainty. Chi-square tests of independence indicated that the manipulation was successful: χ^2 = 130.68, p < .001; χ^2 = 523.54, p < .001; and χ^2 = 135.55, p < .001. Participants in the pseudoscientific content conditions correctly identified the presence of statistics or numerical findings at rates ranging from 82% to 98%. Table A2, part I, presents the distribution of certainty levels. Participants exposed to messages containing pseudoscientific content reported significantly greater certainty about the presence of pseudoscientific information than those in control or no-pseudoscientific-content conditions.

We also examined whether the inclusion of pseudoscientific information affected the perceived difficulty of understanding the messages. Participants in the conditions containing pseudoscientific content were consistently less likely to rate the messages as "very easy" (rating 1) compared to those in the non-statistical and control conditions (χ^2 = 973.96, p < .001).

3. *Censorship manipulation*

The censorship manipulation was assessed using two questions measuring the presence of censorship cues. A chi-square test of independence confirmed that the manipulation was successful (χ^2 = 468.63, p < .001), with more than 89% of participants in the censorship conditions correctly identifying the cues. Participants in the censored conditions reported significantly greater certainty that the messages contained censorship claims than those in the non-censored conditions (see Table A2, part II).

4. *Pseudoscience and censorship claim recognition*

Finally, we assessed whether participants had encountered pseudoscientific statistics and censorship claims in their surveys (see Table A2, part III). Asked at the very end of manipulation checks, we showed the partial screenshots of actual message components to the respondents and asked if they had seen those during the exposure. The results demonstrated highly significant differences across conditions for both the pseudoscientific stats check (χ^2 = 621.406, p < .001) and the censorship claims check (χ^2 = 477.111, p < .001). These results indicate that participants accurately identified the presence or absence of pseudoscientific stats and censorship accusations across experimental conditions, with recognition rates exceeding 90% in the intended conditions for both features.

Table A2. *Distribution of certainty levels and manipulation checks across experimental conditions.*

		Vaccination topic				GMO topic			
Condition	Control	No stats No cens	No stats Cens	Stats No cens	Stats Cens	No stats No cens	No stats Cens	Stats No cens	Stats Cens
Total N	106	107	98	91	101	105	95	100	97
I. Certainty of statistics presence									
(1) Not at all certain to (7) Extremely certain	24%	28%	33%	7%	11%	27%	28%	5%	7%
	13%	19%	17%	9%	14%	13%	12%	11%	11%
	21%	14%	15%	9%	12%	10%	9%	16%	24%
	15%	8%	13%	21%	16%	15%	8%	14%	12%
	6%	12%	4%	5%	5%	9%	8%	10%	7%
	9%	4%	9%	14%	12%	10%	15%	16%	16%
	12%	15%	8%	35%	31%	16%	19%	28%	22%
II. Certainty of censorship presence									
(1) Not at all certain to (7) Extremely certain	27%	36%	7%	16%	7%	33%	5%	20%	6%
	12%	14%	8%	18%	8%	9%	6%	12%	10%
	12%	16%	5%	12%	10%	10%	13%	20%	14%
	13%	11%	19%	18%	14%	14%	5%	14%	11%
	13%	11%	8%	11%	7%	10%	7%	13%	11%
	6%	2%	14%	11%	16%	10%	18%	8%	12%
	16%	10%	38%	14%	39%	12%	45%	13%	34%
III. Tables/Figures manipulation checks									
Statistics check									
Present	11%	11%	13%	98%	97%	10%	19%	97%	94%
Absent	89%	89%	87%	2%	3%	90%	81%	3%	6%
Censorship Check									
Present	11%	22%	93%	37%	99%	19%	96%	40%	98%
Absent	89%	78%	7%	63%	1%	81%	4%	60%	2%

Part 4: Characterizing pseudoscience and examples of misinformation

Pseudoscience definitions vary widely. Pseudoscience is a multidimensional, complex construct, and there is a longstanding *demarcation* problem between science and pseudoscience in the philosophy of science and the theoretical literature (determining what can be defined as distinctly pseudoscience as opposed to science) (Boudry, 2022; Hansson, 2025). In line with these, we characterized pseudoscientific health misinformation in a way that can include examples of both completely made-up statistics and misleading/unverified representations of publicly available (generally epidemiological) datasets, among a list of some common features that philosophers and theorists laid out, which include strong deviations from scientific procedures, norms such as cherry-picking (hand-picking examples) and disregard of refuting information (Hansson, 2025). Others highlighted science denialism as a form of pseudoscience too (Hansson, 2017). Recent work recognizes and compares these diverse forms of pseudoscience in the context of misinformation research (Kuru, 2026a).

Pseudoscientific reports that exhibit these characteristics have proliferated, particularly during the COVID-19 pandemic in recent years. Pseudoscience was used to spread misinformation about vaccines and to market health products and false/unproven remedies for infectious diseases (Chavda et al., 2022; Skafle et al., 2022). Our hypothetical misinformation messages were modelled after some high-profile examples (e.g., claims of large-scale excess deaths across countries correlating with vaccination rates, and the like; see illustrative examples further below in this Appendix) and included both completely made-up and misrepresentation/misinterpretation elements to test their potential effects. Messages did not include any source cues, real or fake; they focused only on comparing the presence vs. absence of pseudoscience in the misinformation.

Hence, our study's aim is not to settle or contribute to theoretical debates about what constitutes pseudoscience, nor to single out specific examples that can be characterized as pseudoscience, but to offer evidence on the potential effects of pseudoscientific content through carefully designed, scientifically looking messages, within the context of health misinformation.

Excess mortality statistics and causal claims regarding COVID-19 vaccines:

- https://alexberenson.substack.com/p/florida-tells-young-men-to-avoid
- https://jamescintolo.substack.com/p/new-study-found-a-9-times-increased?publication_id=548165&isFreemail=true&utm_medium=email
- https://dailysceptic.org/2022/12/24/huge-spikes-in-neonatal-deaths-following-vaccine-rollout-data-from-major-israeli-health-insurer-show/
- https://kirschsubstack.com/p/new-big-data-study-of-145-countries
- https://kirschsubstack.com/p/it-is-now-known-that-the-covid-vaccines?utm_source=profile&utm_medium=reader2
- https://kirschsubstack.com/p/two-top-cardiologists-implicate-covid?utm_source=profile&utm_medium=reader2
- https://www.reuters.com/article/factcheck-gbnews-excessdeaths-idUSL1N3180Q7
- https://www.snopes.com/fact-check/vaccination-rate-excess-deaths/
- https://healthfeedback.org/claimreview/covid-19-vaccines-reduce-risk-death-contrary-to-mark-steyns-misleading-interpretation-mortality-data-gb-news/
- https://healthfeedback.org/claimreview/scientific-evidence-shows-covid-19-vaccination-reduces-risk-infection-mortality-analysis-cases-deaths-from-145-countries-methodologically-flawed-steve-kirsch/
- https://stevekirsch.substack.com/p/exclusive-proof-that-the-top-israeli
- https://www.factcheck.org/2022/08/scicheck-widespread-claims-misrepresent-effectiveness-of-covid-19-vaccines/
- https://www.heart.org/en/news/2022/08/22/covid-19-infection-poses-higher-risk-for-myocarditis-than-vaccines

GMO safety and misconceptions:

- World Health Organization: https://www.who.int/news-room/questions-and-answers/item/food-genetically-modified
- https://www.mdpi.com/2304-8158/9/4/522
- https://journals.sagepub.com/doi/10.1177/209660831900200407
- "The author noted that an analysis by Heilongjiang Soybean Association had shown that GM soybeans were highly correlated with the incidence of tumours, and the results were shocking. The article also mentioned that foreign countries had already disclosed information on the correlation between them, citing studies by Russian scientist Alexey Surov in 2010 and French

scientist Gilles-Eric Seralini in 2012 as evidence. This article attracted considerable attention. Despite denials by professional media and scientists the following day, the rumour that 'GM soybeans cause cancer' spread rapidly."

- https://news.harvard.edu/gazette/story/2023/09/is-organic-better/

Appendix B: Power and sensitivity analysis

Part 1: Power analysis

We conducted an a priori power analysis to determine the required sample size. Since research on the effects of censorship claims and pseudoscientific content on misinformation beliefs is relatively scarce, we grounded our estimates in the broader field of misinformation studies. One meta-analysis (Schmid & Bauer, 2025) showed that exposure to health-related misinformation increased false beliefs (g = 0.24). Additionally, O'Brien et al. (2021) demonstrated that misleading claims that embedded scientific content had small-to-medium effects on individuals' belief perceptions. Based on these findings and large-scale field interventions reported by Roozenbeek et al. (2022), we adopted conservative effect sizes of f = 0.15 and f = 0.20.

We employed G*Power to conduct an ANOVA (fixed effects, special, main effects, and interactions) to calculate the required sample size given α (0.05), power, and effect size. We used two different power thresholds: 80% (conventional standard) and 95% (conservative standard), with α = 0.05. We used the most conservative setting, with a numerator df of 8 (9 conditions - 1).

The power analysis yielded the following required sample sizes:

- Effect size f = 0.15, 95% power: N = 1,019
- Effect size f = 0.15, 80% power: N = 676
- Effect size f = 0.20, 95% power: N = 577
- Effect size f = 0.20, 80% power: N = 384

Our final analytical sample size is 900, which meets three of the four benchmarks above. We are therefore confident that our sample size provides adequate power to detect the manipulation effects of interest. However, for interaction effects, please see the following sections (Part 2 and Part 3 in Appendix B) below.

Part 2: Sensitivity analysis

We conducted a post hoc sensitivity analysis to determine the minimum three-way interaction effect detectable at several levels of statistical power. Each issue-specific moderation model included 397 participants, seven predictors including the one three-way interaction term, and 389 residual degrees of freedom. With a nominal two-sided alpha of .05, the models had 80%, 75%, and 70% power to detect incremental effects of Cohen's f^2 = .0199, .0176, and .0156, respectively. The statistically significant three-way interactions had Cohen's f^2 values ranging from .0161 to .0180 (see Table B1). Thus, the observed effects were above the 70% sensitivity threshold; the two scientific-populism interactions were also slightly above the 75% threshold, but none reached the 80% power threshold. Although these interactions were statistically significant in the present sample, effects of this magnitude may not be detected consistently across replications. The findings should therefore be interpreted cautiously and replicated in studies specifically powered to detect higher-order interactions for more conclusive findings on these individual difference moderators.

Table B1. *Sensitivity results for three-way interaction models.*

Outcome	Moderator	*N*	*b*	*SE*	*t*	*p*	Adjusted R^2	Cohen's f^2
Vaccine risk perception	Subjective numeracy	397	−0.661	0.264	−2.501	0.013	0.018	0.0161
Vaccination intention	Subjective numeracy	397	0.088	0.292	0.302	0.763	0.028	0.0002
GMO risk perception	Subjective numeracy	397	−0.225	0.264	−0.851	0.395	−.002	0.0019
GMO consumption intention	Subjective numeracy	397	0.068	0.294	0.23	0.818	0.01	0.0001
Vaccine risk perception	Scientific populism	397	0.485	0.315	1.539	0.125	0.119	0.0061
Vaccination intention	Scientific populism	397	−0.979	0.37	−2.645	0.008	0.014	0.018
GMO risk perception	Scientific populism	397	−0.477	0.304	−1.572	0.117	0.041	0.0063
GMO consumption intention	Scientific populism	397	0.894	0.338	2.642	0.009	0.053	0.0179

Note: Each row reports the three-way interaction among pseudoscientific content, censorship accusations, and the specified moderator. The b-values are unstandardized regression coefficients, and the p-values are based on two-sided tests. Cohen's f^2 represents the incremental contribution of the focal three-way interaction and was calculated as t^2 divided by the residual degrees of freedom.

Part 3: False discovery rate adjustment

To address multiple testing across the higher-order interaction models, we applied the Benjamini–Hochberg (BH) false discovery rate procedure within three conceptually distinct (as pre-registered) outcome families: credibility, vaccine-related outcomes, and GMO-related outcomes. The credibility family included four three-way interaction tests, one for each moderator. The vaccine family included eight tests across vaccine risk and vaccination intention, and the GMO family included eight tests across GMO risk and GMO consumption intention. The moderators were subjective numeracy (main paper), scientific populism (main paper), trust in science (appendix result), and need for cognition (appendix result). This family structure reflects differences in the outcome constructs and analytical samples: credibility was pooled across the vaccine and GMO topics, whereas the vaccine and GMO outcomes were measured in separate topic-specific subsamples.

The BH procedure ranks the unadjusted *p*-values within each family and adjusts them according to their rank and the number of tests in that family (Benjamini & Hochberg, 1995). The resulting BH-adjusted *p*-value, referred to here as the *q* value, indicates whether a result remains significant while controlling the expected proportion of false discoveries among the results declared significant within that family. Thus, $q < .05$ controls the false discovery rate at 5%; it does not mean that each significant result has a 5% probability of being false.

In addition to the BH adjustment, we also tested for a more conservative Bonferroni adjustment. Bonferroni controls the family-wise probability of making one or more Type I errors and hence is possible to lead to false negatives as well. Thus, we present results under both adjustment procedures to assess the robustness of the findings.

Results for both adjustment robustness checks are in Table B2: Table B2 reports the unadjusted *p*-values, within-family BH-adjusted *p*-values (*q*-values), and Bonferroni-adjusted *p* values.

BH Results: Of the 20 exploratory three-way interactions, two of the interactions reported in the main text remained significant after the within-family BH-FDR adjustment. These were the subjective numeracy interaction for vaccine risk and the scientific populism interaction for vaccination intention. The scientific populism interaction for GMO consumption intention was significant before adjustment but did not remain significant after BH-FDR adjustment ($p = .009$, $q = .069$).

Bonferroni Results: None of the interactions remained significant under the more conservative within-family Bonferroni adjustment. We treat the BH-FDR results as the primary multiplicity analysis and present the Bonferroni results as a stricter sensitivity analysis. Collectively, these results support cautious interpretation of the higher-order interactions.

Table B2*. Three-way interaction models with within-family Benjamini-Hochberg FDR and Bonferroni adjustments.*

Family	Moderator	Outcome	*b*	*SE*	*t*	*p*	BH-FDR *q*	Bonferroni *p*
Credibility	Subjective numeracy	Credibility	-0.247	0.157	-1.573	0.116	0.411	0.464
Vaccine outcomes	Subjective numeracy	Vaccine risk	-0.661	0.264	-2.501	0.013	0.034	0.102
Vaccine outcomes	Subjective numeracy	Vaccination intention	0.088	0.292	0.302	0.763	0.763	1
GMO outcomes	Subjective numeracy	GMO risk	-0.225	0.264	-0.851	0.395	0.632	1
GMO outcomes	Subjective numeracy	GMO consumption intention	0.068	0.294	0.23	0.818	0.858	1
Credibility	Scientific populism	Credibility	-0.018	0.181	-0.1	0.92	0.949	1
Vaccine outcomes	Scientific populism	Vaccine risk	0.485	0.315	1.539	0.125	0.216	0.997
Vaccine outcomes	Scientific populism	Vaccination intention	-0.979	0.37	-2.645	0.008	0.034	0.068
GMO outcomes	Scientific populism	GMO risk	-0.477	0.304	-1.572	0.117	0.467	0.935
GMO outcomes	Scientific populism	GMO consumption intention	0.894	0.338	2.642	0.009	0.069	0.069
Credibility	Trust in science	Credibility	-0.188	0.149	-1.267	0.206	0.411	0.823
Vaccine outcomes	Trust in science	Vaccine risk	-0.397	0.265	-1.498	0.135	0.216	1
Vaccine outcomes	Trust in science	Vaccination intention	0.214	0.289	0.742	0.458	0.611	1
GMO outcomes	Trust in science	GMO risk	-0.284	0.246	-1.156	0.248	0.497	1

Family	Moderator	Outcome	*b*	*SE*	*t*	*p*	BH-FDR *q*	Bonferroni *p*
GMO outcomes	Trust in science	GMO consumption intention	0.358	0.275	1.303	0.193	0.497	1
Credibility	Need for cognition	Credibility	-0.011	0.172	-0.064	0.949	0.949	1
Vaccine outcomes	Need for cognition	Vaccine risk	-0.81	0.299	-2.708	0.007	0.034	0.056
Vaccine outcomes	Need for cognition	Vaccination intention	0.156	0.336	0.463	0.643	0.735	1
GMO outcomes	Need for cognition	GMO risk	0.093	0.284	0.328	0.743	0.858	1
GMO outcomes	Need for cognition	GMO consumption intention	-0.057	0.32	-0.18	0.858	0.858	1

Note: Each row reports the three-way interaction among pseudoscientific content, censorship accusations, and the specified moderator. The credibility models pooled the vaccine and GMO topics and controlled for topic; the vaccine and GMO models were estimated in their respective topic-specific experimental subsamples. The b-values are unstandardized regression coefficients, and the p-values are based on two-sided tests. BH-adjusted p-values, referred to as q-values, were calculated separately within the credibility family (four tests), vaccine-outcome family (eight tests), and GMO-outcome family (eight tests). A value of q < .05 indicates significance under a 5% false discovery rate within the corresponding family. Bonferroni-adjusted p-values were calculated within the same families and provide a more conservative test controlling the familywise error rate.

Appendix C: Analytical rationale, pre-registration, and additional analysis

Part 1: Analytical rationale

The unrelated Control condition

We had an unrelated, equivalent condition (N = 106) with a reading task on the rules of baseball that included some numerical details (to balance against conditions that varied in numerical content). We did not have a true statistics/accurate information control condition given 1) the ecological validity concerning the whole experiment (censorship accusations do not make sense), 2) this is not a misinformation intervention study (where it is more relevant to have accurate control conditions to check for spillover cynicism effects), 3) outcome was not about misinformation discernment (e.g., between fake and real news headlines etc.). The current study examines the specific features (tactics used) in misinformation messages, and the unrelated control condition provides a comparative benchmark for all outcome variables, especially risk perceptions and behavioral intentions (Guay et al., 2023).

Our design implemented an unrelated control condition to provide a neutral baseline free from health-related priming effects, ensuring that any observed differences reflect exposure to health misinformation itself. Our full-factorial eight experimental conditions provided different versions of health misinformation messages; hence, results are compared both among similar content that varies only in manipulation factors and among more dissimilar content (with respect to the unrelated control condition). As we compare whether and how distinct experimental conditions differ from this unrelated baseline, we can make inferences about the manipulations. This is one advantage of unrelated controls. We note that unrelated controls are also widely used in prior experimental studies on misinformation, including tobacco- and e-cigarette-related studies (see Albarracin et al., 2018; Wright et al., 2021). More broadly, this approach is not uncommon in misinformation research: a systematic review of 64 RCTs (randomized controlled trials) found that 15 (23%) studies used unrelated messages as the control condition (Schmid et al., 2023).

However, an unrelated control also has disadvantages in some circumstances, and the interpretation of effects needs to be communicated carefully. During the design, we carefully weighed the pros and cons of this decision. We struggled to find equivalent health misinformation that would be equidistant from both of the theoretical manipulations (pseudoscience and censorship accusation). In particular, the presence or absence of pseudoscience manipulation makes an unrelated control necessary; using a related health misinformation control condition instead would have introduced the characteristics of the "pseudoscience absent" condition as well, rendering the robust isolation of this effect implausible. In future research in this area, this challenge could be partially addressed by including multiple (at least two) related control conditions, which we ruled out in this work due to design symmetry, sample size, statistical power, and budget constraints. While it is not necessarily a limitation, it is a point that should be carefully communicated in interpreting and contextualizing the effects.

Analytical considerations

For credibility outcomes, we collapsed across vaccine and GMO topics because credibility reflects a general assessment of message believability rather than topic-specific attitudes. The misinformation stimuli were structurally parallel across topics, differing only in substantive issue content, which allowed us to isolate the general effects of pseudoscientific features and censorship accusations on perceived credibility. Pooling across topics also increases statistical precision for detecting these general message effects. At the same time, we acknowledge that vaccine and GMO misinformation may operate somewhat differently across contexts; therefore, issue-specific credibility results are also presented separately in the main text. However, risk perception and behavioral intention were analyzed separately by topic because vaccine and GMO attitudes represent distinct behavioral contexts with different underlying beliefs. For the moderation analyses involving pre-existing individual differences, we estimated three-way interactions using OLS and excluded the control condition because participants in the control group were not exposed to any misinformation; therefore, the moderation mechanisms (how individual differences condition responses to misinformation features) are not applicable or comparable to the experimental conditions.

Part 2: Pre-registration analysis

While our study includes several pre-registered moderators, we prioritized two variables in the main paper: subjective numeracy and science populism. Each of these moderators is theoretically the most proximal and relevant construct, subjective numeracy as the individual difference indexing susceptibility to pseudoscience content, and scientific populism is the individual difference indexing susceptibility to censorship accusations. We also pre-registered two moderators: trust in science and need for cognition (NFC); see Table C1 for descriptive analysis. Trust in science and NFC are reported here.

Trust in science was measured using four items adapted from Nadelson et al. (2014) and O'Brien et al. (2021), rated on a 7-point scale ranging from 1 (Not at all true) to 7 (Extremely true):

- Scientific theories are trustworthy
- Scientific methods are reliable
- Scientific findings and knowledge acquired from science are credible
- Science is a trustworthy way to understand the world we live in

NFC was measured using six items from Cacioppo and Petty (1982), rated on a 7-point scale ranging from 1 (Not at all true) to 7 (Extremely true):

- I would prefer complex to simple problems
- I like to have the responsibility of handling a situation that requires a lot of thinking
- Thinking is NOT my idea of fun (reverse-coded)
- I would rather do something that requires LITTLE thought than something that is sure to challenge my thinking abilities (reverse-coded)
- I really enjoy a task that involves coming up with new solutions to problems
- I would prefer a task that is intellectual, difficult, and important to one that is somewhat important but does not require much thought

In Tables C2 and C3, we present the results for these pre-registered moderators. Trust in science did not significantly moderate the effects of pseudoscientific content. NFC did not significantly moderate the effects of pseudoscientific content, but it moderated the effects of censorship accusations on GMO risk perceptions and GMO consumption intentions. No corresponding NFC × censorship interactions were observed for credibility or vaccine-related outcomes. Future research could incorporate additional indicators of processing depth to better understand the cognitive mechanisms underlying responses to pseudoscientific content.

Our survey also included a non-pre-registered moderator: objective numeracy. Although this moderator was not pre-registered, we included it to better understand the differences between objective and subjective numeracy (which was pre-registered) in processing misinformation containing statistical information. Regarding the objective numeracy scale (5 items), the initial internal consistency (Cronbach's alpha) was 0.56. We conducted a sensitivity analysis to determine if deleting items could meaningfully improve reliability. Removing one item (d.num3r) only marginally increased the standardized alpha to 0.57. We also tested all possible 3-item combinations (deleting two items), but the highest alpha achieved was only 0.53. It is important to note that a relatively lower alpha is understandable for an objective performance measure like this one. Unlike subjective scales that measure attitudes or feelings through similar questions to tap underlying psychological constructs, objective performance tests consisting of specific math problems do not fully imply consistent performance across all items.

Table C1. *Descriptive results for two moderators.*

Variable	**Mean**	***SD***	**Min**	**Median**	**Max**	**Cronbach Alpha**
Trust in science	0.51	0.23	0	0.5	1	0.94
NFC	0.47	0.2	0	0.47	1	0.79

Table C2. *Moderation results for trust in science.*

(Predictors)	**M1: Credibility**	**M2: Vax risk**	**M3: Vax intention**	**M4: GMO risk**	**M5: GMO intention**
(Intercept)	b = 0.20, SE = 0.03 p < .001	b = 0.43, SE = 0.06 p < .001	b = 0.27, SE = 0.06 p < .001	b = 0.46, SE = 0.05 p < .001	b = 0.43, SE = 0.05 p < .001
Manip1 (Pseudoscience)	b = 0.06, SE = 0.04 p = .144	b = 0.05, SE = 0.07 p = .530	b = -0.15, SE = 0.08 p = .059	b = 0.01, SE = 0.07 p = .940	b = 0.05, SE = 0.08 p = .497
Trust Science	b = 0.28, SE = 0.05 p < .001	b = 0.09, SE = 0.10 p = .339	b = 0.22, SE = 0.10 p = .034	b = 0.10, SE = 0.08 p = .235	b = 0.09, SE = 0.09 p = .321
Manip2 (Censor)	b = -0.04, SE = 0.02 p = .035	b = -0.04, SE = 0.03 p = .184	b = 0.05, SE = 0.03 p = .134	b = -0.02, SE = 0.03 p = .465	b = 0.03, SE = 0.03 p = .434
Manip3 (GMO)	b = 0.03, SE = 0.02 p = .091	—	—	—	—
Interaction (Trust* Pseudoscience)	b = 0.04, SE = 0.07 p = .593	b = -0.04, SE = 0.13 p = .748	b = 0.27, SE = 0.14 p = .063	b = 0.07, SE = 0.12 p = .539	b = -0.24, SE = 0.14 p = .076
Model fit					
R2	0.107	0.009	0.073	0.02	0.021
F-statistic	18.78	0.93	7.66	1.98	2.12
Model p-value	<.001	0.449	<.001	0.097	0.078

Table C3. *Moderation results for NFC.*

(Predictors)	M1: Credibility	M2: Vax risk	M3: Vax intention	M4: GMO risk	M5: GMO intention
Panel A: NFC × Pseudoscientific Content					
(Intercept)	*b* = 0.23 (0.03) *p* < .001	*b* = 0.47 (0.06) *p* < .001	*b* = 0.31 (0.06) *p* < .001	*b* = 0.49 (0.05) *p* < .001	*b* = 0.44 (0.06) *p* < .001
Manip1 (Pseudoscience)	*b* = 0.04 (0.04) *p* = .377	*b* = -0.08 (0.07) *p* = .261	*b* = -0.08 (0.08) *p* = .318	*b* = 0.03 (0.07) *p* = .732	*b* = -0.06 (0.08) *p* = .481
NFC	*b* = 0.24 (0.06) *p* < .001	*b* = 0.03 (0.11) *p* = .765	*b* = 0.17 (0.12) *p* = .170	*b* = 0.05 (0.10) *p* = .637	*b* = 0.07 (0.11) *p* = .497
Manip2 (Censor)	*b* = -0.04 (0.02) *p* = .012	*b* = -0.04 (0.03) *p* = .138	*b* = 0.03 (0.03) *p* = .345	*b* = -0.02 (0.03) *p* = .451	*b* = 0.03 (0.03) *p* = .388
Manip3 (GMO)	*b* = 0.03 (0.02) *p* = .123	—	—	—	—
Interaction (NFC* Pseudoscience)	*b* = 0.09 (0.09) *p* = .286	*b* = 0.24 (0.15) *p* = .108	*b* = 0.14 (0.16) *p* = .392	*b* = 0.04 (0.14) *p* = .795	*b* = -0.02 (0.16) *p* = .902
R2	0.086	0.025	0.028	0.009	0.015
F-statistic	14.76	2.47	2.78	0.87	1.47
Model *p*-value	<.001	0.044	0.026	0.483	0.212

Panel B: NFC × Censorship Accusation

(Predictors)	M1: Credibility	M2: Vax risk	M3: Vax intention	M4: GMO risk	M5: GMO intention
(Intercept)	*b* = 0.23 (0.03) *p* < .001	*b* = 0.37 (0.05) *p* < .001	*b* = 0.26 (0.06) *p* < .001	*b* = 0.62 (0.06) *p* < .001	*b* = 0.33 (0.06) *p* < .001
Manip2 (Censor)	*b* = -0.09 (0.04) *p* = .040	*b* = 0.04 (0.08) *p* = .600	*b* = 0.05 (0.08) *p* = .533	*b* = -0.28 (0.07) *p* < .001	*b* = 0.26 (0.08) *p* = .002
NFC	*b* = 0.24 (0.06) *p* < .001	*b* = 0.24 (0.10) *p* = .015	*b* = 0.26 (0.11) *p* = .016	*b* = -0.22 (0.10) *p* = .033	*b* = 0.31 (0.11) *p* = .006
Manip1 (Pseudoscience)	*b* = 0.08 (0.02) *p* < .001	*b* = 0.03 (0.03) *p* = .373	*b* = -0.02 (0.03) *p* = .578	*b* = 0.04 (0.03) *p* = .131	*b* = -0.07 (0.03) *p* = .035
Manip3 (GMO)	*b* = 0.03 (0.02) *p* = .110	— —	— —	— —	— —
	b = 0.10 (0.09)	*b* = -0.18 (0.15)	*b* = -0.05 (0.17)	*b* = 0.54 (0.14)	*b* = -0.47 (0.16)

Interaction (NFC × Censorship)	*p* = .245	*p* = .228	*p* = .767	*p* < .001	*p* = .003
R2	0.086	0.022	0.026	0.044	0.037
F-statistic	14.81	2.18	2.62	4.51	3.74
Model *p*-value	<.001	.070	.035	.001	.005

Note: Panels A and B report separate two-way moderation models. Each model controls for the other experimental manipulation. Standard errors are in parentheses.

Table C4 summarizes and distinguishes departures from the pre-registration from presentational prioritization.

Table C4. *Deviations from and clarifications to the pre-registered analysis plan.*

Original bullet points in the pre-registration (pre-registered hypothesis or design/analysis item, before data collection)	**Eventual implementation and deviation notes (after data collection)**
H1: Misinformation with statistics will be more persuasive.	No deviation. The manuscript uses the more precise term *pseudoscientific content* because the manipulation combined fabricated statistics, a statistical table, formal scientific language, and an unwarranted causal interpretation.
H2: Misinformation with censorship will be more persuasive.	No deviation.
H3: Presence of statistics and censorship combined will be more persuasive (interaction between the two manipulations).	No deviation.
H4: Effects of statistics will be moderated by trust in science, such that individuals higher in trust in science will be more susceptible to the effects of statistics in misinformation.	No deviation. The pre-registered two-way moderation analyses were reported in Appendix C, Part 2. The main text prioritizes subjective numeracy and scientific populism as the moderators most proximal to the manipulations.
H5: Effects of statistics will be moderated by perceived numeracy, such that individuals higher in perceived numeracy will be more susceptible to the effects of statistics in misinformation.	No deviation. The three-way interaction including censorship accusations was an exploratory extension.
H6: Effects of censorship claims will be moderated by scientific populism; the effects of censorship will be stronger among individuals higher in scientific populism.	No deviation. The three-way interaction including pseudoscientific content was an exploratory extension.
RQ: How does need for cognition influence processing of statistics and censorship claims?	No deviation. The pre-registered two-way moderation analyses were reported in Appendix C, Part 2. The main text prioritizes subjective numeracy and scientific populism as the moderators most proximal to the manipulations.

Original bullet points in the pre-registration (pre-registered hypothesis or design/analysis item, before data collection)	**Eventual implementation and deviation notes (after data collection)**
Key dependent variables: Perceived message credibility, vaccination- and GMO-related risk perceptions, and behavioral intentions.	No deviation.
Experimental conditions: One unrelated control and eight misinformation conditions crossing topic, statistics, and censorship claims.	No deviation.
Planned analyses: ANCOVA and OLS models testing main effects, interactions, and theoretical moderators.	Analysis clarification. Because the randomized experimental cells were balanced, unadjusted ANOVA and OLS models were emphasized as the primary analyses.
Exclusion criteria: Failure of either attention check, the accuracy pledge, or the speeding criterion.	No deviation.
Sample size: N = 900 good completes.	No deviation.
Objective numeracy.	Not pre-registered. Objective numeracy was added as an exploratory measure. Because the scale showed low internal consistency, its reliability assessment and the decision not to emphasize it are discussed in Appendix C, Part 2.

Note. The pre-registration is available at https://aspredicted.org/FJW_MCH.

Part 3: Additional analysis

To ensure the robustness of our findings, we conducted supplementary analyses of perceived risks associated with GMOs and vaccinations using three distinct analytical approaches. These two variables were selected for additional analysis because they were the dependent variables measured at both pre-test and post-test. For risk perceptions, we measured both post-test levels and post–pre-test difference scores ($M_{vaccine}$ = .06, SD_{vaccine} = .22, M_{GMO} = .10, SD_{GMO} = .29).

1. Model 1 (Main Manuscript Analysis): This model utilizes only post-test scores as the dependent variables (DVs) to examine main effects.
2. Model 2 (Difference Scores): This model employs ANOVA with post-test minus pre-test difference scores as the DVs. It should be noted that the pre-test used a single-item set to minimize participant fatigue and potential (pre)testing effects. However, recent research shows such pre-tests rarely induce bias (Sheagley & Clifford, 2025). Specifically:
    - GMO Risk Pre-test: How risky do you think the side effects of eating genetically modified foods are? (7-point Likert scale: 1 [Not at all risky] to 7 [Extremely risky]).
    - Vaccination Risk Pre-test: How risky do you think the side effects of COVID-19 vaccines are? (7-point Likert scale: 1 [Not at all risky] to 7 [Extremely risky]).
3. Model 3 (ANCOVA): To account for within-individual variance, we conducted an ANCOVA using pre-test scores as covariates and post-test scores as the DVs.

The results, summarized in Table C5, demonstrate that our findings are largely consistent across all three models. Regarding the main effects, consistent with our main analysis, we did not find any significant treatment effects on the perceived risk of vaccination (See Figure C1 for a difference-score visualization). Regarding moderation analyses, no significant interaction effects were found for the GMO issue. While the difference score and ANCOVA models revealed some additional patterns, we have opted to report the post-test-only model in the main manuscript. This decision was made because the pre-test measures captured only specific dimensions of risk perception, whereas the post-test measures provided a more comprehensive assessment.

Table C5. *Additional results for main effects and moderation.*

Section	**DV**	**Post-test DV only**	**DIFF (difference scores)**	**ANCOVA**
Main effects	Perceived risks of GMO	Control - Pseudo_NoCens: lower Control - Pseudo_Cens: lower	Control - NoPseudo_NoCens: lower Control - Pseudo_NoCens: lower Control - Pseudo_Cens: lower NoPseudo_Cens - Pseudo_NoCens: lower	Control - NoPseudo_NoCens: lower Control - Pseudo_NoCens: lower Control - Pseudo_Cens: lower NoPseudo_Cens - Pseudo_NoCens: lower
Moderation	Perceived risks of vaccine (subjective numeracy)	(Three-way interaction) Pseudo-Cens-Numeracy		

Note: Pseudo_NoCens = Pseudoscientific content without Censorship; Pseudo_Cens = Pseudoscientific content with Censorship; NoPseudo_Cens = No pseudoscientific content with Censorship; Control = Control Group. Blue text (e.g., Control - Pseudo_NoCens) indicates consistent results across all three analytical methods. Orange text indicates new patterns that emerged only in the difference score and ANCOVA methods. Red text indicates inconsistencies among Post DV, the difference score, and the ANCOVA methods. For all comparisons (e.g., A - B: lower), the first condition showed lower values than the second condition.

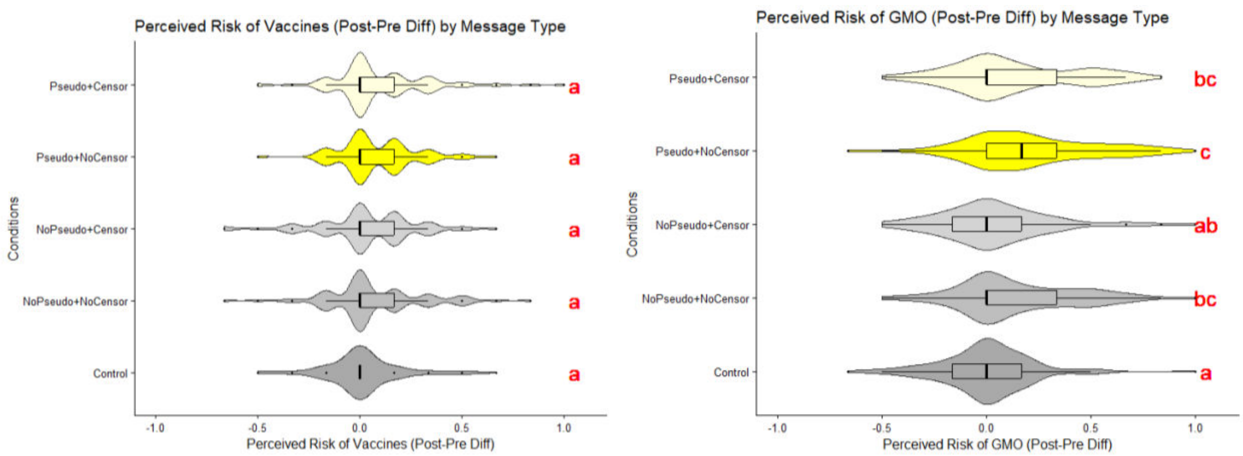

Figure C1. Perceived risk(diff). *Conditions sharing a common letter are not significantly different (*p *> .05), while those with distinct letters differ significantly (*p *< .05).*

Part 4: Collapsed analysis for the moderation effect (Control as the reference group)

We conducted supplementary moderation analyses using a collapsed five-level factor, with the control condition as the reference group. This approach allows us to assess how moderators interact with each experimental condition relative to the control condition, rather than estimating the moderation of the factorial design's main effects in isolation. Consistent with our primary analysis, we focus on subjective numeracy and science populism as moderators.

The results are presented in Table C6, which is largely consistent with our main manuscript. For vaccination risk, subjective numeracy significantly moderated the effect of pseudoscientific content without censorship accusation relative to control, b = 0.52, SE = 0.19, p = .007. For vaccination intention, science populism significantly moderated the effect of pseudoscientific content without censorship accusation relative to control, b = 0.72, SE = 0.26, p = .007. For the GMO intention, science populism significantly moderated the effects of no pseudoscientific content with a censorship accusation (b = −0.56, SE = 0.25, p = .027) and of pseudoscientific content without a censorship accusation b = −0.66, SE = 0.25, p = .009) relative to the control.

Table C6. *Moderation effects of subjective numeracy and science populism on experimental condition (vs. Control).*

DV	Moderator	Condition	*b*	*SE*	*t*	*p*	CI_low	CI_high	adj_R2
Credibility	Subjective numeracy	noPseudo × noCens	-0.006	0.131	-0.043	0.966	-0.262	0.251	0.058
		noPseudo × Cens	-0.005	0.132	-0.038	0.97	-0.263	0.253	
		Pseudo × noCens	0.202	0.132	1.527	0.127	-0.058	0.461	
		Pseudo × Cens	-0.048	0.132	-0.366	0.715	-0.309	0.212	
	Science populism	noPseudo × noCens	0.248	0.164	1.506	0.133	-0.075	0.571	0.153
		noPseudo × Cens	0.299	0.163	1.834	0.067	-0.021	0.619	

DV	Moderator	Condition	*b*	*SE*	*t*	*p*	CI_low	CI_high	adj_R2
		Pseudo × noCens	0.231	0.163	1.41	0.159	-0.09	0.551	
		Pseudo × Cens	0.276	0.171	1.609	0.108	-0.061	0.612	
Perceived risks of vaccine	Subjective numeracy	noPseudo × noCens	0.197	0.175	1.126	0.261	-0.147	0.542	0.018
		noPseudo × Cens	0.254	0.185	1.374	0.17	-0.109	0.618	
		Pseudo × noCens	0.524	0.193	2.723	0.007	0.146	0.903	
		Pseudo × Cens	-0.079	0.177	-0.447	0.655	-0.427	0.269	
	Science populism	noPseudo × noCens	0.108	0.22	0.489	0.625	-0.324	0.54	0.114
		noPseudo × Cens	-0.17	0.22	-0.774	0.439	-0.602	0.262	
		Pseudo × noCens	0.028	0.221	0.127	0.899	-0.406	0.462	
		Pseudo × Cens	0.235	0.253	0.929	0.353	-0.262	0.732	
Vax intention	Subjective numeracy	noPseudo × noCens	-0.045	0.198	-0.226	0.822	-0.434	0.344	0.028
		noPseudo × Cens	0.006	0.209	0.028	0.977	-0.405	0.417	
		Pseudo × noCens	0	0.218	0.001	0.999	-0.427	0.428	
		Pseudo × Cens	0.139	0.2	0.694	0.488	-0.254	0.532	
	Science populism	noPseudo × noCens	0.104	0.263	0.397	0.692	-0.413	0.622	0.015
		noPseudo × Cens	0.489	0.263	1.857	0.064	-0.028	1.007	
		Pseudo × noCens	0.719	0.264	2.722	0.007	0.2	1.238	
		Pseudo × Cens	0.125	0.303	0.412	0.68	-0.47	0.72	
Perceived risks of GMO	Subjective numeracy	noPseudo × noCens	0.129	0.184	0.7	0.485	-0.233	0.491	0.024
		noPseudo × Cens	0.07	0.179	0.392	0.695	-0.281	0.421	
		Pseudo × noCens	0.322	0.176	1.834	0.067	-0.023	0.667	
		Pseudo × Cens	0.038	0.19	0.202	0.84	-0.336	0.413	
	Science populism	noPseudo × noCens	-0.249	0.23	-1.08	0.281	-0.702	0.204	0.067

DV	Moderator	Condition	*b*	*SE*	*t*	*p*	CI_low	CI_high	adj_R2
		noPseudo × Cens	0.089	0.224	0.396	0.692	-0.351	0.529	
		Pseudo × noCens	-0.012	0.225	-0.052	0.958	-0.454	0.431	
		Pseudo × Cens	-0.151	0.234	-0.647	0.518	-0.611	0.308	
GMO intention	Subjective numeracy	noPseudo × noCens	0.062	0.206	0.303	0.762	-0.342	0.467	0.021
		noPseudo × Cens	0.073	0.199	0.366	0.714	-0.319	0.464	
		Pseudo × noCens	-0.195	0.196	-0.993	0.321	-0.58	0.19	
		Pseudo × Cens	-0.116	0.213	-0.547	0.585	-0.534	0.301	
	Science populism	noPseudo × noCens	0.023	0.259	0.09	0.929	-0.485	0.531	0.054
		noPseudo × Cens	-0.556	0.251	-2.213	0.027	-1.05	-0.062	
		Pseudo × noCens	-0.664	0.253	-2.626	0.009	-1.161	-0.167	
		Pseudo × Cens	-0.35	0.262	-1.332	0.183	-0.865	0.166	

Note: Each cell reports the interaction coefficient (b) between experimental condition and moderator from a separate OLS regression model, with Control as the reference group. noPseudo × noCens = no pseudoscientific content, no censorship accusation; noPseudo × Cens = no pseudoscientific content with censorship accusation; Pseudo × noCens = pseudoscientific content without censorship accusation; Pseudo × Cens = pseudoscientific content with censorship accusation. Credibility was modeled using the full sample (N = 900); Vax Risk and Vax Intention were modeled using vaccine-domain participants plus the control group (N = 503); GMO Risk and GMO Intention were modeled using GMO-domain participants plus the control group (N = 503). SE = standard error; CI = 95% confidence interval; adj. R² reported per model.

Part 5: Further discussion on potential psychological mechanisms and applied recommendations

In this study, our main focus was on identifying the effects of two important aspects of pseudoscience and censorship accusations in sophisticated health misinformation, with a focus on the "persecuted hero narrative." We also tested the theoretically relevant moderators (pre-existing individual differences) to understand the conditions and contextual effects of these messages. However, we did not investigate the underlying psychological/cognitive mechanisms behind these effects, which could be examined using mediators; this can be addressed in future research. Agreeing with the reviewer's points during the peer review process, we think that heuristic versus systematic processing is highly relevant for exploring cognitive mechanisms. We examined the need for cognition (NFC) as a potential moderator of responses to pseudoscientific content. NFC is a construct closely related to depth of processing. However, it is more of a general individual difference than a situational occurrence, unlike the systematic vs. heuristic routes in dual-processing models. We did not observe significant interaction effects for NFC with pseudoscientific content (see Appendix C, Part 2). At the same time, we did not directly measure other indicators of processing depth, such as counterarguing. Therefore, we are unable to make direct inferences/claims about the cognitive mechanisms underlying these message/media effects. Our moderators provide us with some insights, but they do not focus on individuals' elaboration likelihood when they encounter this type of misinformation. One plausible interpretation is that high subjective numeracy-related overconfidence likely leads to heuristic/peripheral processing (reliance on cues and facilitation of snap judgments rather than careful attention), thereby producing these effects (greater susceptibility to pseudoscience). However, this is just one possibility, and we did not elaborate on this in the hypothesis/pre-registration, so we do not want to present it as the paper's central theoretical framing. These theoretical mechanisms should be investigated in future work in this line of research.

Appendix D: Survey instruments and materials

Part 1: Survey instruments

Perceived credibility of information

dv1. How informative do you find the information you just read?

1. Not at all informative
2. A little informative
3. Somewhat informative
4. Informative
5. Quite informative
6. Very informative
7. Extremely informative

dv2. How reliable do you find the information you just read?

1. Not at all reliable
2. A little reliable
3. Somewhat reliable
4. Reliable
5. Quite reliable
6. Very reliable
7. Extremely reliable

dv3. How accurate do you find the information you just read?

1. Not at all accurate
2. A little accurate
3. Somewhat accurate
4. Accurate
5. Quite accurate
6. Very accurate
7. Extremely accurate

dv4. How valid do you find the information you just read?

1. Not at all valid
2. A little valid
3. Somewhat valid
4. Valid
5. Quite valid
6. Very valid
7. Extremely valid

dv5. How scientific do you find the information you just read?

1. Not at all scientific
2. A little scientific
3. Somewhat scientific
4. Scientific

5. Quite scientific
6. Very scientific
7. Extremely scientific

COVID-19 vaccines

dvvax1. How risky do you think the side effects of COVID-19 vaccines are?
1. Not at all risky
2. A little risky
3. Somewhat risky
4. Risky
5. Quite risky
6. Very risky
7. Extremely risky

dvvax2. How concerned are you about the side effects of COVID-19 vaccines?
1. Not at all concerned
2. A little concerned
3. Somewhat concerned
4. Concerned
5. Quite concerned
6. Very concerned
7. Extremely concerned

dvvax3. How worried are you about the side effects of COVID-19 vaccines?
1. Not at all worried
2. A little worried
3. Somewhat worried
4. Worried
5. Quite worried
6. Very worried
7. Extremely worried

Genetically modified foods

dvgmo1. How risky do you think the side effects of eating genetically-modified foods are?
1. Not at all risky
2. A little risky
3. Somewhat risky
4. Risky
5. Quite risky
6. Very risky
7. Extremely risky

dvgmo2. How concerned are you about the side effects of eating genetically-modified foods?
1. Not at all concerned
2. A little concerned
3. Somewhat concerned

4. Concerned
5. Quite concerned
6. Very concerned
7. Extremely concerned

dvgmo3. How worried are you about the side effects of eating genetically-modified foods?
1. Not at all worried
2. A little worried
3. Somewhat worried
4. Worried
5. Quite worried
6. Very worried
7. Extremely worried

Behavioral intentions

dvvax4. How likely are you to get a COVID-19 vaccine (or booster shot) in future if health authorities recommend it for your age group?
1. Not at all likely
2. A little likely
3. Somewhat likely
4. Likely
5. Quite likely
6. Very likely
7. Extremely likely

dvgmo4. How likely are you to avoid buying food that is genetically-modified (GMO) in future?
1. Not at all likely to avoid GMO
2. A little likely to avoid GMO
3. Somewhat likely to avoid GMO
4. Likely to avoid GMO
5. Quite likely to avoid GMO
6. Very likely to avoid GMO
7. Extremely likely to avoid GMO

Objective numeracy

num1. Which of the following numbers represents the biggest risk of getting a disease?
1. 1 in 100
2. 1 in 1000
3. 1 in 10

num2. If Person A's chance of getting a disease is 1% in ten years, and person B's risk is double that of A's, what is B's risk in ten years?
1. 0.5%
2. 2%
3. 5%

num3. If the chance of getting a disease is 10%, how many people would be expected to get the disease out of 1000?

1. 10
2. 100
3. 50

num4. If the chance of getting a disease is 20 out of 100, what is the percentage risk of getting the disease?

1. 5%
2. 10%
3. 20%

num5. The chance of getting a viral infection is .0005. Out of 10,000 people, how many of them are expected to get infected?

1. 5
2. 50
3. 500

Subjective numeracy

Q1. How good are you at working with fractions?

1. Not at all good
2. A little good
3. Somewhat good
4. Good
5. Quite good
6. Very good
7. Extremely good

Q2. How good are you at working with percentages?

1. Not at all good
2. A little good
3. Somewhat good
4. Good
5. Quite good
6. Very good
7. Extremely good

Q3. How good are you at calculating a 15% tip?

1. Not at all good
2. A little good
3. Somewhat good
4. Good
5. Quite good
6. Very good
7. Extremely good

Q4. How good are you at figuring out how much a shirt will cost if it is 25% off?
1. Not at all good
2. A little good
3. Somewhat good
4. Good
5. Quite good
6. Very good
7. Extremely good

Q5. When reading the newspaper, how helpful do you find tables and graphs that are parts of a story?
1. Not at all helpful
2. A little helpful
3. Somewhat helpful
4. Helpful
5. Quite helpful
6. Very helpful
7. Extremely helpful

Q6. When people tell you the chance of something happening, do you prefer that they use words ("it rarely happens") or numbers ("there's a 1% chance")?
1. Always prefer words
2. Mostly prefer words
3. Usually prefer words
4. Prefer words and numbers about equally
5. Usually prefer numbers
6. Mostly prefer numbers
7. Always prefer numbers

Q7. When you hear a weather forecast, do you prefer predictions using words (e.g., "there is a small chance of rain today") or predictions using percentages (e.g., "there will be a 20% chance of rain today")?
1. Always prefer words
2. Mostly prefer words
3. Usually prefer words
4. Prefer words and percentages about equally
5. Usually prefer percentages
6. Mostly prefer percentages
7. Always prefer percentages

Q8. In general, how much do you find numerical information as helpful?
1. Not at all helpful
2. A little helpful
3. Somewhat helpful
4. Helpful
5. Quite helpful
6. Very helpful
7. Extremely helpful

Scientific populism

pop1 - Please evaluate the following statements to reflect your views. How true are the following statements according to you?

1. What unites the ordinary people is that they trust their common sense in everyday life.
   1. Not at all true
   2. A little true
   3. Somewhat true
   4. True
   5. Quite true
   6. Very true
   7. Extremely true

2. Ordinary people are of good and honest character.
   1. Not at all true
   2. A little true
   3. Somewhat true
   4. True
   5. Quite true
   6. Very true
   7. Extremely true

3. Scientists are only after their own advantage.
   1. Not at all true
   2. A little true
   3. Somewhat true
   4. True
   5. Quite true
   6. Very true
   7. Extremely true

4. Scientists are in cahoots with politics and business.
   1. Not at all true
   2. A little true
   3. Somewhat true
   4. True
   5. Quite true
   6. Very true
   7. Extremely true

5. The people should have influence on the work of scientists.
   1. Not at all true
   2. A little true
   3. Somewhat true
   4. True
   5. Quite true
   6. Very true
   7. Extremely true

6. People like me should be involved in decisions about the topics scientists research.
    1. Not at all true
    2. A little true
    3. Somewhat true
    4. True
    5. Quite true
    6. Very true
    7. Extremely true

7. In case of doubt, one should rather trust the life experience of ordinary people than the estimations of scientists.
    1. Not at all true
    2. A little true
    3. Somewhat true
    4. True
    5. Quite true
    6. Very true
    7. Extremely true

8. We should rely more on common sense and less on scientific studies.
    1. Not at all true
    2. A little true
    3. Somewhat true
    4. True
    5. Quite true
    6. Very true
    7. Extremely true

Demographic and other control variables

1. Are you:
    1. Male
    2. Female
    3. Other

2. What is your ethnicity?
    1. Chinese
    2. Malay
    3. Indian
    4. Other

3. What is the highest level of school you have completed or the highest degree you have received?
    1. Primary school or less
    2. Some high school but no diploma
    3. High school graduate
    4. Some college but no degree
    5. Polytechnic
    6. Bachelor’s degree in college (4-year)

7. Master's degree
8. Doctoral degree
9. Professional degree

4. How old are you?

5. Last year -- that is, in 2023 -- what was the average MONTHLY income of all the people living in your house or apartment BEFORE taxes in Singaporean Dollars (SGD)?
1. $1000 or less
2. $1001 to $3000
3. $3001 to $5000
4. $5001 to $7000
5. $7001 to $9000
6. $9001 to $11000
7. $11001 to $13000
8. $13001 to $15000
9. $15001 to $17000
10. $17001 to $20000
11. $20001 to $25000
12. More than $25000

6. Generally speaking, would you describe your political views as:
1. Very conservative
2. Somewhat conservative
3. Moderate; middle of the road
4. Somewhat liberal
5. Very liberal
6. Do not want to respond

7. In the past 14 days, how often have you used the following sources to get news and information? (A) Print newspapers/(B) TV news/(C) Online news websites/(D) Facebook
1. Never
2. Once in the past 14 days
3. Once per week
4. 2-3 times per week
5. 4-6 times per week
6. Once every day
7. 2-3 times every day
8. 4-5 times every day
9. More than 5 times every day

Part 2: Experimental material

1.Control condition

Baseball Rules
Baseball is a sport that dates back as far as 1,744 and formats of the game have been in place until the modern era today. The game is predominantly big in North America, Canada and Japan. The game is

played worldwide with the pinnacle of sport coming from the World Series of Baseball. Ironically, this event is only competed by North American teams.

Objective of the Game
The objective of baseball is to score more runs than your opponent. The idea is to hit the ball thrown at you as far as you can before running around 4 bases to complete a run. Once a player manages to get around the four bases before being tagged out, then another batter steps in.

Key rules
A game is played out between two teams, each made up of 9 players. The game lasts for 9 innings with each team alternating between batting and fielding in each inning. The scores at the end of the innings are added to a cumulative score and the team with most points wins. Each team has three outs per inning before they then swap roles.

The bats are made out of either wood, aluminium or metal materials. The ball is white with red stitching and is roughly 3 inches in diameter. The fielding team wear 'mits', which are basically an oversized glove to help them catch and pick up the ball. The catcher (standing behind the batter to catch any balls missed) wears extra padding in their glove, along with leg guards, a body pad, and a helmet.

(Reference: <www.rulesofsport.com>)

2. Vaccine messages without pseudoscientific content/censorship

DANGERS of COVID-19 Vaccine Side Effects: Vaccination and Death!
COVID-19 vaccines have dangerous side effects that may cause unexplained injuries and deaths among otherwise healthy individuals. There has been reports across many countries that there are many vaccinated individuals who developed serious health conditions or died suddenly after taking a booster shot, despite being healthy.

Vaccination frequently causes serious negative effects on health and deaths among healthy individuals. Hence, the claim that COVID-19 vaccines are safe and that serious side effects are rare is not accurate.

The side effects of the vaccine are neither mild nor short term. These side effects did not resolve quickly as well. This is extremely concerning. While vaccine maker bio-technology companies have listed some common mild effects and acknowledged some serious side effects happening very rarely, this is not true. Dangerous side effects of vaccines are very common. Vaccines for COVID-19 can cause a severe allergic reaction for many individuals, especially those who are administered multiple doses. These then lead to long term problems including heart conditions and people die suddenly although these individuals were fully healthy before vaccination. This is not rare at all. That COVID-19 vaccination leads to death frequently even among healthy individuals is a very serious problem about their side effects.

3. Vaccine messages with censorship messages/without pseudoscientific content

DANGERS of COVID-19 Vaccine Side Effects: Vaccination and Death!
COVID-19 vaccines have dangerous side effects that may cause unexplained injuries and deaths among otherwise healthy individuals. There has been reports across many countries that there are many vaccinated individuals who developed serious health conditions or died suddenly after taking a booster shot, despite being healthy.

Vaccination frequently causes serious negative effects on health and deaths among healthy individuals. Hence, the claim that COVID-19 vaccines are safe and that serious side effects are rare is not accurate.

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4. Vaccine messages with pseudoscientific content/without censorship

DANGERS of COVID-19 Vaccine Side Effects: CORRELATION between Vaccination and Death Rates! COVID-19 vaccines have dangerous side effects that may cause unexplained injuries and deaths among otherwise healthy individuals. There has been reports across many countries that there are many vaccinated individuals who developed serious health conditions or died suddenly after taking a booster shot, despite being healthy. Here are the findings from recent epidemiological research on how COVID-19 vaccines can lead to serious problems including deaths (mortality):

"An analysis of data from 164 countries found a positive correlation between COVID-19 vaccination rates and the number of serious health problems such as heart failure and excess deaths across the countries, Pearson's Correlation r = .22, 95% Confidence Intervals [.19, .25], statistical significance p < .001. This finding means that there are more unexplained serious health problems and deaths in countries where vaccination rates are higher. Vaccines have serious side effects on a wide scale in the population that can even lead to death."

Country type group	Percentage	Heart failure and excessive deaths
High rate vaccination	*75%*	.217*** [.092 - .125], p<. 001
Medium rate vaccination	*45%*	.073*** [.054 - .094], p<. 001
Low rate vaccination	*27%*	.009** [.007 - .011], p<. 003

Table. *Group-based statistical testing of the association between vaccination rate and heart failure and excessive unexplained deaths across the 164 countries in the study.*

Vaccination frequently causes serious negative effects on health and deaths among healthy individuals. Hence, the claim that COVID-19 vaccines are safe and that serious side effects are rare is not accurate. Vaccines can cause severe allergic reactions. These then lead to long term problems including heart conditions and people die suddenly despite being healthy previously.

5. Vaccine messages with pseudoscientific content/censorship

DANGERS of COVID-19 Vaccine Side Effects: CORRELATION between Vaccination and Death Rates! COVID-19 vaccines have dangerous side effects that may cause unexplained injuries and deaths among otherwise healthy individuals. There has been reports across many countries that there are many vaccinated individuals who developed serious health conditions or died suddenly after taking a booster shot, despite being healthy. Here are the findings from recent epidemiological research on how COVID-19 vaccines can lead to serious problems including deaths (mortality):

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6. GMO messages without pseudoscientific content/censorship

DANGERS of Genetically modified (GM) foods: GM food consumption and cancer deaths!
Genetically modified (GM) foods are very dangerous for human health as they can frequently cause serious unexplained allergies and death. There has been reports across many countries that increasing use of some GM foods can cause serious allergies that can even lead to cancer and death, even among healthy individuals.

GM foods frequently causes serious negative effects on health and even cancer and deaths among healthy individuals. Hence, the claim that genetically modified foods are safe and that serious side effects are rare is not accurate.

The side effects of the genetically modified (GM) foods are neither mild nor short term. These side effects did not resolve quickly as well. This is extremely concerning. While gene-modifying bio-technology companies have listed some common mild effects and acknowledged some serious side effects happening very rarely, this is not true. Dangerous side effects of GMO are very common. Genetically modified foods can cause a severe allergic reaction for many individuals, especially over the long term. These then lead to long term problems including cancer and eventual death. This is not rare at all. That GMOs lead to cancer and death frequently even among healthy individuals is a very serious problem about their side effects.

7. GMO messages without pseudoscientific content/with censorship

DANGERS of Genetically modified (GM) foods: GM food consumption and cancer deaths!
Genetically modified (GM) foods are very dangerous for human health as they can frequently cause serious unexplained allergies and death. There has been reports across many countries that increasing use of some GM foods can cause serious allergies that can even lead to cancer and death, even among healthy individuals.

GM foods frequently causes serious negative effects on health and even cancer and deaths among healthy individuals. Hence, the claim that genetically modified foods are safe and that serious side effects are rare is not accurate.

The side effects of the genetically modified (GM) foods are neither mild nor short term. These side effects did not resolve quickly as well. This is extremely concerning. While gene-modifying bio-technology companies have listed some common mild effects and acknowledged some serious side effects happening very rarely, this is not true. Dangerous side effects of GMO are very common. Genetically modified foods can cause a severe allergic reaction for many individuals, especially over the long term. These then lead to long term problems including cancer and eventual death. This is not rare at all.

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8. GMO messages with pseudoscientific content/without censorship

DANGERS of Genetically modified (GM) foods: CORRELATION between GM food consumption and cancer deaths!

Genetically modified (GM) foods are very dangerous for human health as they can frequently cause serious unexplained allergies and death. There has been reports across many countries that increasing use of some GM foods can cause serious allergies that can even lead to cancer and death, even among healthy individuals. Here are the findings from recent epidemiological research on how GM soybeans can cause cancer and ultimately death (mortality):

“An analysis in 164 countries found a positive correlation between the average domestic consumption of GM soybean products and the number of serious health problems such as serious food allergies and excess cancer-related deaths across the countries, Pearson’s Correlation $r = .22$, 95% Confidence Intervals [.19, .25], statistical significance $p < .001$. This finding means that there are more allergy related health problems and cancer deaths in countries where the domestic consumption of GM soybean products is higher.”

Country type group	Percentage	Serious allergy and cancer related deaths
High rate use of GMO	*75%*	.217*** [.092 - .125], p<. 001
Medium rate use of GMO	*45%*	.073*** [.054 - .094], p<. 001
Low rate use of GMO	*27%*	.009** [.007 - .011], p<. 003

Table. *Group-based statistical testing of the association between genetically-modified food use rate and serious allergy and cancer related deaths across the 164 countries in the study.*

GM foods frequently causes serious negative effects on health and even cancer and deaths among healthy individuals. Hence, the claim that genetically modified foods are safe and that serious side effects are rare is not accurate. Genetically modified foods can cause a severe allergic reaction for many individuals, especially over the long-term. These then lead to problems like cancer and death.

9. GMO messages with pseudoscientific content/censorship

DANGERS of Genetically modified (GM) foods: CORRELATION between GM food consumption and cancer deaths!

Genetically modified (GM) foods are very dangerous for human health as they can frequently cause serious unexplained allergies and death. There has been reports across many countries that increasing use of some GM foods can cause serious allergies that can even lead to cancer and death, even among healthy individuals. Here are the findings from recent epidemiological research on how GM soybeans can cause cancer and ultimately death (mortality): “An analysis in 164 countries found a positive correlation between the average domestic consumption of GM soybean products and the number of serious health problems such as serious food allergies and excess cancer-related deaths across the countries, Pearson’s Correlation $r = .22$, 95% Confidence Intervals [.19, .25], statistical significance $p < .001$. This finding means that there are more allergy related health problems and cancer deaths in countries where the domestic consumption of GM soybean products is higher.”

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Appendix E: Pilot study

We have conducted a pilot study employing the same manipulation in different contexts. A pre-registered pilot study (*N* = 1,225) was conducted in Singapore to examine the influence of pseudoscientific content and accusations of censorship on misinformed beliefs about COVID-19 vaccine side effects, with a specific focus on claims about excess mortality rates. Employing a 2 (pseudoscientific content vs. no pseudoscientific content) *2 (censorship: presence vs. absence) * 2 (platform: health blog vs. messaging application) between-subjects factorial design, the study did not include a neutral control group, relying instead on comparative effects between misinformation versions.

Results indicated that the mere inclusion of pseudo-statistical details (pseudoscience)—such as correlation coefficients and confidence intervals—did not significantly alter belief in misinformation or sharing intentions. Conversely, accusations of censorship produced a "backfire effect," significantly reducing respondents' intentions to share the information on social media compared to messages without such claims.

The study also revealed a critical boundary condition for these main effects: a significant interaction between pseudoscientific content and censorship claims. When pseudoscientific content was combined with censorship accusations, participants reported greater belief in the accuracy of the misinformation than in conditions where censorship claims appeared in isolation. Still, the overall effect sizes were small.

It is also important to note that the nature of the manipulation in this pilot study was somewhat different: it did not include a table of statistical results, and only statistical findings were reported in parentheses within the text. We determined it had a weak dosage manipulation, and some people may not have paid attention to the few statistical details. Data were also collected at a peak time (higher infection rates) during the pandemic. See further discussion below in the manipulation checks section.

Manipulation checks results in the pilot study: We included two manipulation check questions. The first task asked participants to identify the content they had read, offering one correct and three incorrect response options. The second task asked them to select all applicable content features from a list of 10 items (5 correct, 5 incorrect). The first manipulation checks generally performed well. However, the second question yielded mixed results: pseudoscientific content manipulation: Of 606 respondents exposed to messages with pseudo-statistics, only 171 (28.2%) correctly indicated having seen statistics.

Censorship manipulation: Of 597 respondents exposed to censorship claims, only 141 (23.6%) correctly identified this element.

Platform manipulation: Of 606 respondents shown a Substack-like blog format, 367 (60.6%) correctly identified it. Of 619 respondents shown a WhatsApp-like messaging application format, only 110 (17.8%) correctly identified it, while 169 (27.3%) incorrectly reported seeing a Substack-like blog post.

The pilot study provided valuable insights but also revealed methodological limitations that we addressed in the current study. Specifically:

First, the unsatisfactory performance of the second manipulation check question raised concerns about whether participants adequately processed the pseudoscientific content and censorship elements. To address this, we designed multiple more targeted manipulation-check questions in the current studies to ensure that our treatments were properly perceived and processed (see Appendix A for validation results).

Second, the pilot study's focus on COVID-19 vaccine misinformation and its use of presentation formats (health blog vs. messaging app) as experimental stimuli may have lacked ecological validity. In practice, detailed misinformation containing statistics appears more commonly in certain contexts than others. Therefore, in the current study, we deliberately selected two distinct topics to examine whether the interaction between pseudoscientific content and censorship claims generalizes across domains (as a conceptual replication) or represents a topic-specific phenomenon.

Appendix F: Regression results where we treated pseudoscientific content and censorship accusations as independent manipulation factors

Table F1 reports the main and interaction effects of pseudoscientific content and censorship accusation factors across all outcome variables in the main text. These models exclude the control condition, as the factorial regression framework does not accommodate a group that cannot be assigned to a level of either manipulation factor. For comparisons involving the control condition, see the post-hoc pairwise analyses reported in the main text.

Model 1 in Table F1 below includes two dummy-coded predictors: pseudoscientific content (1 = pseudoscientific, 0 = non-pseudoscientific) and censorship accusation (1 = censorship present, 0 = absent), and controls for the topics (GMO and vaccines). Model 2 adds the two-way interaction term between these two factors. Reported coefficients (*b*) are unstandardized. Partial η^2 is estimated from the regression model.

Table F1. *Regression results: main and interaction effects of pseudoscientific content and censorship accusations across outcome variables.*

Outcomes	Model	Predictor term	*b*	*SE*	*t*	*p*	Partial η^2	Adj. R^2
Perceived credibility	Model 1	Pseudoscientific content	0.074	0.018	4.201	<0.001	0.022	0.028
		Censorship accusation	-0.043	0.018	-2.447	0.015	0.008	
	Model 2 (with interaction)	Pseudoscientific content	0.09	0.025	3.616	<0.001	0.016	0.028
		Censorship accusation	-0.028	0.025	-1.124	0.262	0.002	
		Pseudoscientific content × Censorship	-0.031	0.035	-0.891	0.373	0.001	
Vaccine risk per-ceptions	Model 1	Pseudoscientific content	0.022	0.029	0.772	0.441	0.002	0.001
		Censorship accusation	-0.041	0.029	-1.416	0.157	0.005	
	Model 2 (with interaction)	Pseudoscientific content	0.055	0.041	1.335	0.183	0.005	0.002
		Censorship accusation	-0.01	0.04	-0.243	0.808	<0.001	
		Pseudoscientific content × Censorship	-0.065	0.058	-1.116	0.265	0.003	
Vaccination intention	Model 1	Pseudoscientific content	-0.025	0.032	-0.768	0.443	0.001	-0.001

Outcomes	Model	Predictor term	*b*	*SE*	*t*	*p*	Partial η^2	Adj. R^2
		Censorship accusation	0.034	0.032	1.073	0.284	0.003	
	Model 2 (with interaction)	Pseudoscientific content	0.003	0.046	0.076	0.94	<0.001	-0.001
		Censorship accusation	0.062	0.045	1.376	0.17	0.005	
		Pseudoscientific content × Censorship	-0.056	0.064	-0.87	0.385	0.002	
GMO risk per-ceptions	Model 1	Pseudoscientific content	0.042	0.029	1.421	0.156	0.005	0.002
		Censorship accusation	-0.024	0.029	-0.805	0.422	0.002	
	Model 2 (with interaction)	Pseudoscientific content	0.051	0.041	1.26	0.208	0.004	-0.001
		Censorship accusation	-0.013	0.041	-0.326	0.744	<0.001	
		Pseudoscientific content × Censorship	-0.02	0.059	-0.346	0.73	<0.001	
GMO Con-sumption intention	Model 1	Pseudoscientific content	-0.07	0.033	-2.14	0.033	0.011	0.008
		Censorship accusation	0.027	0.033	0.828	0.408	0.002	
	Model 2 (with interaction)	Pseudoscientific content	-0.094	0.046	-2.059	0.04	0.011	0.007
		Censorship accusation	0.003	0.046	0.058	0.954	<0.001	
		Pseudoscientific content × Censorship	0.049	0.065	0.751	0.453	0.001	

Note: Model 1 (Main Effects model) estimates the independent effects of each factor; Model 2 (Interaction model) additionally includes the Pseudoscientific content × Censorship term. Perceived Credibility models additionally control for topic (vaccine vs. GMO). b = unstandardized regression coefficient; SE = standard error; partial η² = partial eta-squared effect size.

Appendix G: Further discussion on findings

Part 1: Asymmetric patterns observed in the GMO and vaccination context

We observed that pseudoscientific content increased GMO risk perceptions and reduced behavioral intentions for GMO consumption, but not for vaccination. This asymmetry likely stems from several interrelated factors.

First, prior experience and entrenched beliefs. Data collection occurred in January 2024, by which point the vast majority of Singaporeans had already received multiple doses of COVID-19 vaccines (Deutsche Welle, 2021), supported by sustained government vaccination campaigns (VacciNationSG, 2021). Vaccination is thus a behavior with which most participants had direct, repeated personal experience (the individual use of preventive medical technology on one's body), making existing attitudes more resistant to change from a single exposure to a message. GMO consumption, by contrast, involves less direct experiential grounding, leaving related attitudes comparatively malleable to informational influence.

Second, social norm dynamics. Studies have shown that perceived injunctive norms strongly correlate with vaccination intention in Singapore (Geber et al., 2023). In a context pronounced for its collectivist culture, expressing vaccine hesitancy may carry a social cost that expressing caution about GMO foods does not. This normative asymmetry may have buffered vaccination intentions against pseudoscientific framing even among participants who found the content credible.

Third, the structure of our behavioral measures. The vaccine intention item asked participants how likely they were to get a booster if health authorities recommended it for their age group, which may invite deference to institutional authority. This specific wording was carefully crafted in the context of the COVID-19 public health emergency and ethical considerations. We note that the question wording ("if health authorities recommend it for your age group?") was carefully designed, given the relatively rapidly evolving booster vaccination recommendations for different age groups at that point during the pandemic, and the question wording reflects the decision-making considerations of individuals more realistically. The GMO intention item carried no equivalent dynamic, leaving it more sensitive to attitudinal shifts. We are nonetheless reasonably confident in the overall validity of our vaccine measure, given Singapore's high-trust institutional context and the measure's alignment with established approaches in the literature (Jolley & Douglas, 2014; Kwok et al., 2021; Wong et al., 2021). Future research may incorporate more diversified behavioral measures to capture the multidimensional nature of vaccination intentions better.

These factors collectively underscore the topic-contingent nature of pseudoscientific persuasion. GMO findings may also be more internationally generalizable, as GMO attitudes are less anchored by strong institutional messaging and may reflect a more neutral attitudinal baseline across a wider range of countries.

Part 2: Science populism's discrete effects between the COVID-19 vaccines and the GMOs

Main points: Among individuals high in scientific populism, exposure to pseudoscientific content alone was associated with higher vaccination intentions but lower GMO consumption intentions. This divergent pattern likely reflects the same interrelated factors discussed above: vaccination in Singapore carries strong normative salience and personal experiential grounding, such that even science-skeptical individuals may not translate institutional distrust into vaccine refusal in this context. GMO consumption, being comparatively neutral and less normatively anchored, remains more susceptible to pseudoscientific framing. This suggests that the behavioral relevance of scientific populism is influenced not only by message framing but also by the extent to which a given issue is institutionally and culturally anchored in the target population.

More detailed discussion: In the Singapore context, vaccination was driven by extensive government campaigns, high institutional trust, repeated personal experience with vaccination, and strong social norms favoring vaccine uptake. As a result, even individuals skeptical toward mainstream science (higher science populism) may not translate this attitude to vaccine refusal in the same way observed in lower-trust or more polarized contexts. Furthermore, communications on vaccine uptake were spearheaded by the Ministry of Health. In contrast, attitudes towards science (science populism) involve other actors, such as vaccine-developing scientists, mostly in other countries (scientists in Singapore were not directly involved in COVID-19 vaccine development). Relatedly, several studies have shown that the country of origin of vaccine development can shape attitudes towards vaccines (e.g., Atkinson et al., 2023). Hence, in hindsight, we interpret it as not entirely implausible that individuals might have divergent attitudes towards scientists and vaccination intentions in a high-trust context where the government spearheads robust norm-based vaccine promotion. This stands in stark contrast to early vaccination efforts and inconsistent messaging from political leaders in the USA (a country where scientists were directly involved in COVID-19 vaccine development). GMO consumption, by contrast, carries weaker normative and experiential anchoring, given that it does not involve tangible action on one's own body and lacks the urgency of the pandemic. These might make GMO-related attitudes more susceptible to pseudoscientific framing. It is also more acceptable to avoid GMOs as a consumption pattern, given the natural/organic food and wellness movements worldwide and, specifically, the widely accepted alternative/complementary health culture in Singapore's public health and medical services repertoire (e.g., Traditional Chinese Medicine) (Lim et al., 2005; Wu & Kuru, 2025).