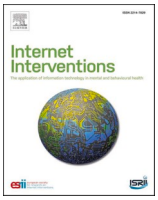
Internet Interventions 35 (2024) 100694

Contents lists available at ScienceDirect

Internet Interventions

journal homepage: www.elsevier.com/locate/invent



Evaluating the impact of short animated videos on COVID-19 vaccine hesitancy: An online randomized controlled trial

Ferdinand Beleites [a], Maya Adam [a,b], Caterina Favaretti [a,c], Violetta Hachaturyan [a], Tilman Kühn [a,d,e], Till Bärnighausen [a,f,g], Sandra Barteit [a,*]

[a] Heidelberg Institute of Global Health (HIGH), Faculty of Medicine and University Hospital, Heidelberg University, Heidelberg, Germany
[b] Department of Pediatrics, Stanford University School of Medicine, Stanford, CA, United States
[c] Behavioral Science for Disease Prevention and Health Care, Technical University of Munich, Munich, Germany
[d] University of Vienna, Department of Nutritional Sciences, Vienna, Austria
[e] Medical University of Vienna, Center for Public Health, Vienna, Austria
[f] Africa Health Research Institute (AHRI), Somkhele, KwaZulu-Natal, South Africa
[g] Harvard Center for Population and Development Studies, T.H. Chan School of Public Health, Cambridge, MA, United States

ARTICLE INFO

Keywords:
Short animated videos
COVID-19
Vaccine hesitancy
Randomized controlled trial
Global Health
Behavior

ABSTRACT

Addressing the global challenge of vaccine hesitancy, amplified during the COVID-19 pandemic due to misinformation propagated via social media, necessitates innovative health communication strategies. This investigation scrutinizes the efficacy of Short, Animated, Story-based (SAS) videos in fostering knowledge, behavioral intent, and engagement around COVID-19 vaccination.

We conducted an online three-arm parallel randomized controlled trial (RCT) involving 792 adult participants (≥18 years, English-speaking) from the United States. The intervention group viewed a SAS video on COVID-19 vaccination, the attention placebo control group watched a SAS video on hope, and the control group received no intervention. Our primary objectives were to assess the influence of SAS videos on knowledge, behavioral intent, and engagement regarding COVID-19 vaccination.

Participants in the intervention group displayed significantly higher mean knowledge scores (20.6, 95 % CI: 20.3–20.9) compared to both the attention placebo control (18.8, 95 % CI: 18.5–19.1, $P < .001$) and control groups (18.7, 95 % CI: 18.4–19.0, $P < .001$). However, SAS videos did not notably affect behavioral intent. Perception of COVID-19 as a significant health threat emerged as a strong predictor for engaging with the post-trial video without further incentives (OR: 0.44; 95 % CI: 0.2–0.96). The 35–44 age group exhibited the highest post-trial engagement ($P = .006$), whereas right-wing political inclination negatively associated with engagement (OR: 1.98; 95 % CI: 3.9–1.01). Vaccination status correlated significantly with self-efficacy ($P < .001$), perceived social norms ($P < .001$), and perceived response efficacy of the COVID-19 vaccine ($P < .001$), all heightened in the intervention group.

These findings suggest that while SAS videos effectively amplify COVID-19 vaccination knowledge, their impact on behavioral intent is not direct. They do, however, affect determinants of vaccination status, thereby indirectly influencing vaccination behavior. The study highlights the appeal of SAS videos among younger audiences, but underscores the need for further examination of factors impeding vaccination engagement. As SAS videos closely mirror conventional social media content, they hold significant potential as a public health communication tool on these platforms.

Trial Registration: Trial was registered at drks.de with the identifier DRKS00027938, on 5 January 2022.

1. Introduction[1]

Public health initiatives have been critically challenged by vaccine

* Corresponding author at: Im Neuenheimer Feld 130.3, 69120 Heidelberg, Germany.
E-mail address: barteit@uni-heidelberg.de (S. Barteit).

[1] APC: Attention Placebo ControlSAS: short, animated story-based video

https://doi.org/10.1016/j.invent.2023.100694
Received 1 June 2023; Received in revised form 15 November 2023; Accepted 25 November 2023
Available online 1 December 2023

Abbreviations

AHRI	Africa Health Research Institute
ANOVA	Analysis of Variance
CI	Confidence Interval
COVID-19	Coronavirus Disease 2019
FDR	False discovery rate
HIGH	Heidelberg Institute of Global Health
JMIR	Journal of Medical Internet Research
OLS	Ordinary Least Squares
OR	Odds Ratio
RCT	randomized controlled trial
US	United States of America

hesitancy, a complex phenomenon contributing to the resurgence of diseases like measles and polio, previously on the verge of eradication (Dubé et al., 2013). This barrier was notably magnified during the COVID-19 pandemic, with misinformation disseminated via social media exacerbating the problem, leading to substantial hindrances in vaccination efforts, heightened risk of severe infections, and increased strain on healthcare systems (Chowdhury et al., 2021; Armocida et al., 2020). Simultaneously, there is burgeoning evidence demonstrating the potential for social media to serve as a powerful conduit for public health promotion (Schillinger et al., 2020). Utilization of these platforms for the dissemination of scientifically validated health information could serve as an effective strategy to counter vaccine hesitancy. Short, animated, story-based (SAS) videos, characterized by their engaging narratives underpinned by evidence-based information, have demonstrated efficacy in enhancing vaccine-related knowledge and modulating behaviors (Vandormael et al., 2021; Mendel-Van Alstyne et al., 2018; Lubis et al., 2022; Zhu et al., 2022; Jensen et al., 2022; Favaretti et al., 2021).

Previous investigations employing SAS videos have yielded mixed results. Vandormael et al. (Vandormael et al., 2021) observed an increase in COVID-19 prevention knowledge following exposure to SAS videos, but the resultant behavior change was partial. Zhu et al. (Zhu et al., 2022) successfully fostered COVID-19 vaccine uptake among a subset of participants using SAS videos, yet the intervention's impact on knowledge acquisition was not evaluated. Jensen et al. (Jensen et al., 2022) reported an augmentation of vaccination intent after exposure to SAS videos, but neither knowledge nor engagement metrics were analyzed. Favaretti et al. (Favaretti et al., 2021) investigated demographic influences on willingness to engage with SAS videos but did not consider beliefs and attitudes towards COVID-19, significant factors in vaccine hesitancy (Du et al., 2021).

To address these gaps, this study deployed an online randomized controlled trial (RCT) to systematically investigate the impact of SAS videos on knowledge acquisition, behavioral intent, and engagement pertaining to COVID-19 vaccination. Our primary objectives were to (1) evaluate the efficacy of SAS videos in augmenting knowledge pertaining to the COVID-19 vaccine, (2) assess their impact on behavioral intent towards vaccination, and (3) elucidate the determinants of intrinsic interest (engagement) in viewing a SAS video about COVID-19 vaccination. Furthermore, we examined the variables contributing to vaccine hesitancy and assessed the intervention's effect on these determinants. This holistic approach aims to yield pertinent insights for devising effective health communication strategies, especially in the face of an ongoing pandemic.

Per our study protocol (Barteit et al., 2022), this is a pilot study evaluating the feasibility of our design. Given its scope of 10,000 participants, it's not powered to discern significant outcomes. Consequently, results are exploratory and primarily inform the upcoming feasibility study.

2. Methods

The study is reported according to the Consolidated Standards of Reporting Trials (CONSORT) checklist (Consort-Statement > CONSORT 2010 > Title, n.d.). Further details are available in the published study protocol (Barteit et al., 2022).

2.1. Trial design

The online RCT followed a multi-arm, parallel design with post-trial access to treatment (see Fig. 1). We randomly assigned participants in a 1:1:1 ratio to one of three study arms (see Fig. 2):

- study arm 1 was a SAS video collage comprised of three individual videos focusing on the central theme of the COVID-19 vaccine
- study arm 2 was exposed to a SAS video broaching on the topic of hope and was therefore unrelated to COVID-19
- study arm 3 was the control group which received no exposure

The trial was registered on 5 January 2022 with the German Clinical Trials Register (www.drks.de) with the number DRKS00027938.

2.2. Study procedures

This study leveraged the capabilities of the online recruitment platform, Prolific Academic Ltd. (Prolific · Quickly find research participants you can trust, n.d.), and the experimental research platform, Gorilla (Cauldron Science Limited) (Gorilla Experiment Builder, n.d.), to conduct a robust online randomized controlled trial (RCT). The initiation of the RCT involved procuring informed consent from participants and gathering basic demographic information. Subsequently, participants were randomly allocated to one of three trial arms: Arm 1 exposed participants to a COVID-19-focused SAS video collage, Arm 2 entailed viewing an attention placebo control (APC) video themed around hope, and Arm 3 functioned as the no-intervention control group.

To ensure participant attention to the presented videos, an attention-check question was asked immediately post-viewing in Arms 1 and 2. This was followed by an assessment comprising 24 multiple-choice questions aimed at gauging participants' COVID-19 vaccine-related knowledge and 18 Likert-scaled items capturing their vaccine-associated self-perceptions (see Outcomes).

Further evaluation of participants' behavioral intent towards COVID-19 vaccination was conducted via a list experiment. Participants from each study arm were allocated using a 1:1 randomization ratio into one of the two groups designated for the list experiment. The study concluded with a questionnaire consisting of seven Likert-scaled items aimed at assessing participants' trust in government bodies, institutions, and healthcare professionals. Participants in Arms 2 and 3 were then given the option of post-trial access to SAS videos. For detailed information regarding the questionnaires and list experiment, please refer to the published study protocol (Barteit et al., 2022).

The study design aimed for an estimated completion time of 10 min, with a time-out exclusion criterion set at 45 min to ensure data quality. Participants were compensated commensurately at a rate of £1.70 per 10 min spent on the study.

2.3. Participants

Study participants in the online RCT were required to be at least 18 years old, native English speakers, and citizens or permanent residents of the United States (US).

The allocation status of participants to the study arms was concealed from both the participants and the trial's researchers. The researchers and data analysts involved in the trial were blinded to group assignments, ensuring the confidentiality of information provided by study participants. Each participant was assigned a unique, anonymous string

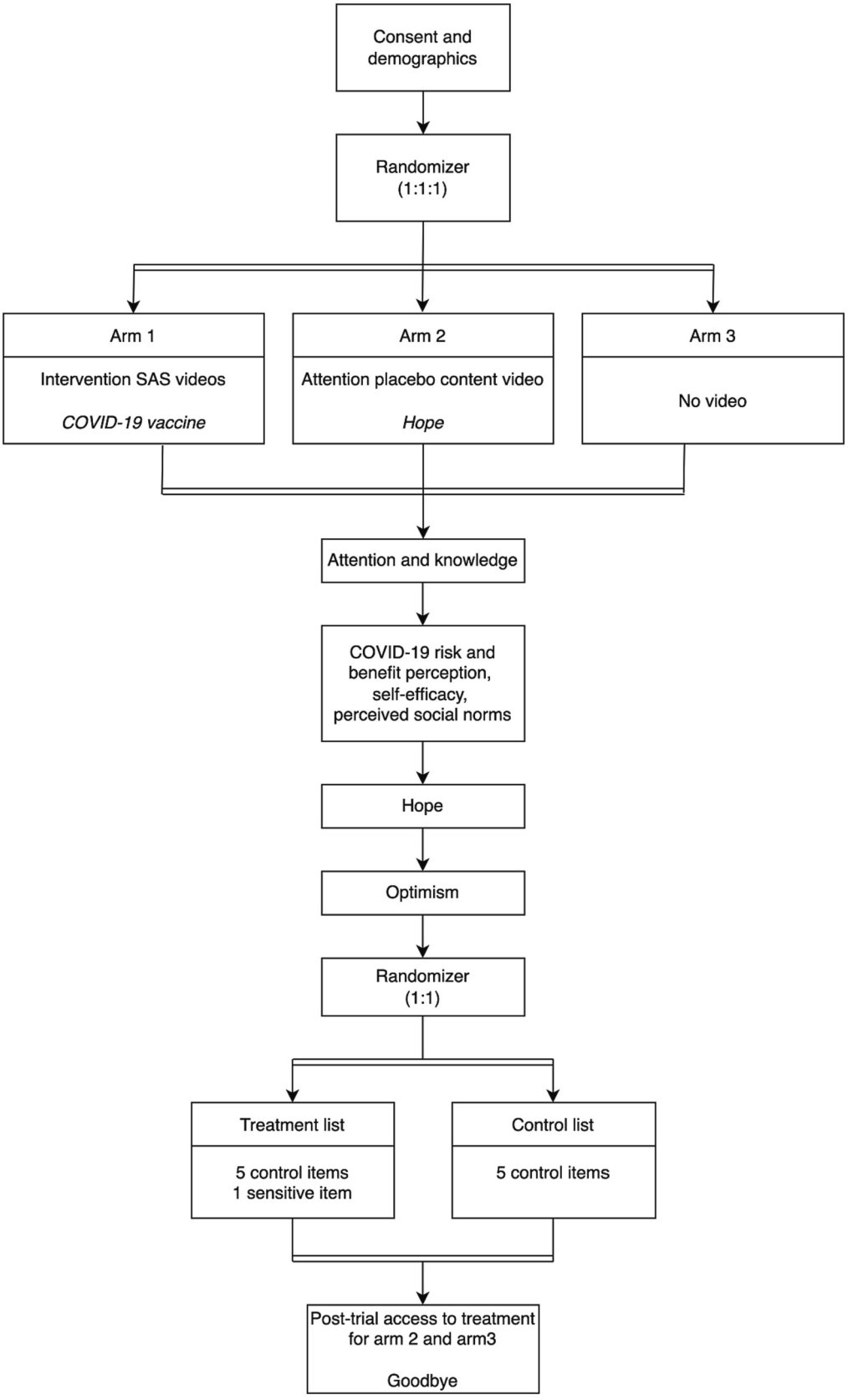


Fig. 1. Trial design of all three arms depicting sequence of randomization, intervention, and outcome measures.

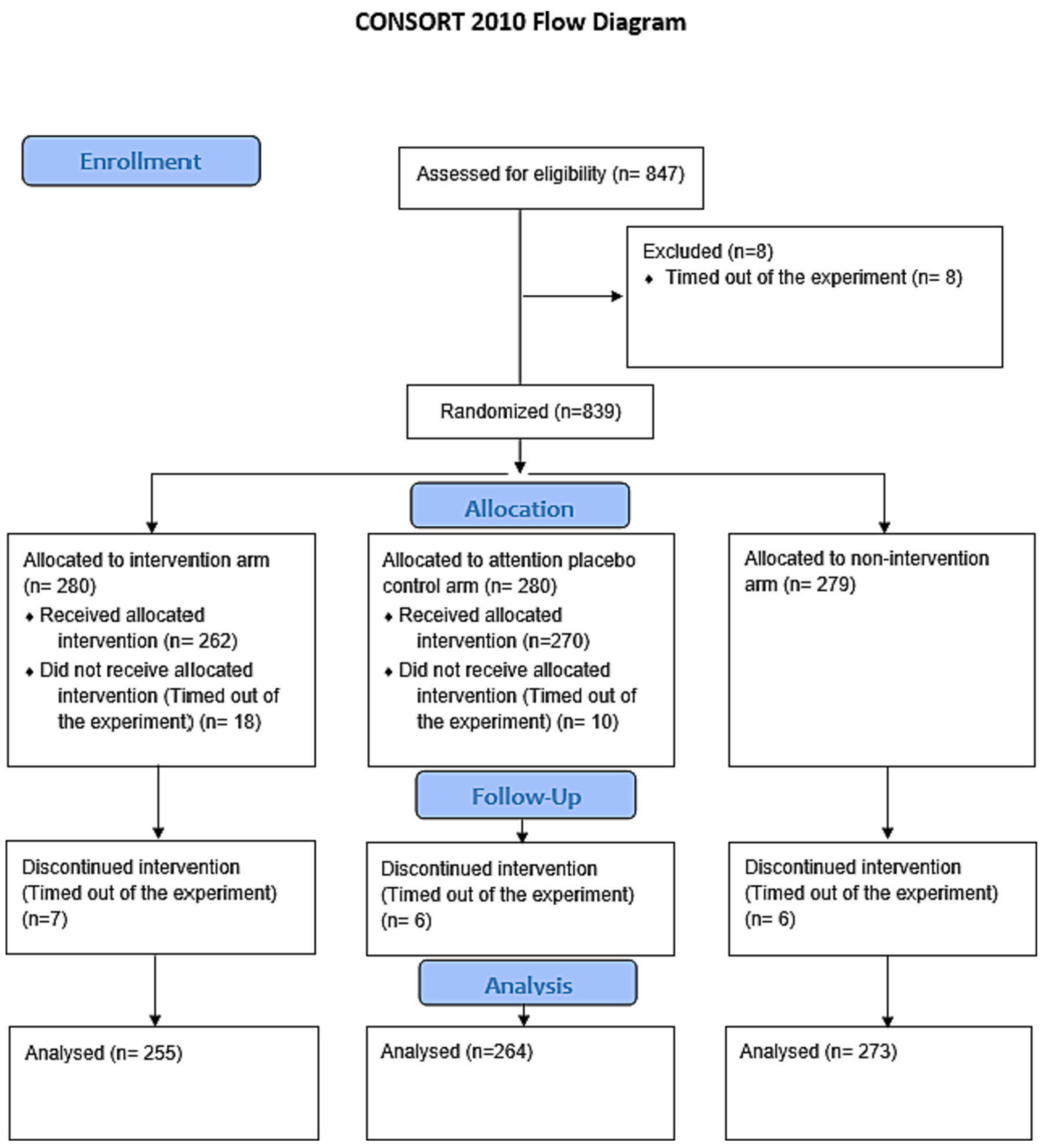


Fig. 2. CONSORT 2010 flow diagram of the online randomized controlled trial using short, animated videos, showing the allocation of participants, as well as providing the number of participants who dropped out and who were analyzed.

identifier linked to their responses on the Gorilla platform.

2.4. Intervention and control

The study's intervention comprised a collage of three Short, Animated, Story-based (SAS) videos, each emphasizing the importance of COVID-19 vaccination (SA_2_VH, 2022). Animated figures, devoid of any explicit ethnic markers, were deployed to preclude cultural biases or alienation.

The intervention included three 4-min SAS videos:

1. "Family and Vaccination" (see Fig. 3): This video illustrates a scenario wherein a healthcare worker offers a COVID-19 vaccine to a family, initially met with refusal from all but the grandmother. The grandmother then elucidates the vaccine's importance, leading to the family's collective acceptance of vaccination.
2. "Gaming Against the Virus" (see Fig. 4): This video adopts a video game metaphor, portraying the coronavirus as an adversarial entity that evolves into stronger variants as it infects hosts. The narrative resolves when human characters opt for vaccination, inhibiting the virus's progression and winning the game.
3. "Societal Access Post-Vaccination" (see Fig. 5): The final video presents a man barred from public spaces and transportation, symbolizing societal exclusion. Upon receiving the COVID-19 vaccine from a doctor, he regains societal participation, marking an emotional transition from desolation to joy.

The videos incorporated segments of text providing specific facts related to vaccines. In the first video, study participants were informed that vaccines have nearly eradicated diseases such as Polio, Smallpox, Diphtheria, Measles, Mumps, Rubella, and Tetanus (see Fig. 3). The subsequent video highlighted several key points about COVID-19

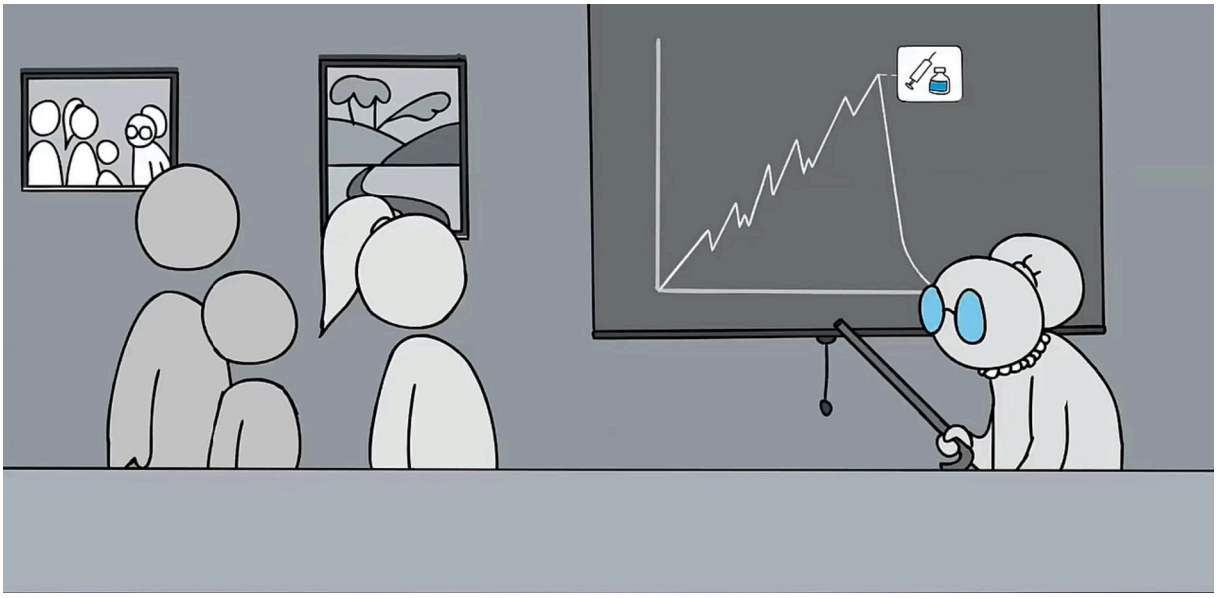


Fig. 3. SAS intervention video 1 “The grandmother”. The video depicts a grandmother (right), who convinces her three family members (left) to get vaccinated against COVID-19.

Fig. 4. SAS intervention video 2 “The video game”. The video shows how the coronavirus (orange diamond shape) passes through levels by infecting humans (orange) and gets hindered by vaccinated humans or those wearing masks (turquoise).

Fig. 5. SAS intervention video 3 “The miserable man”. The video depicts a man (right) who has a miserable day since he is not permitted to attend businesses or transit owing to his lack of vaccination. After he receives a COVID-19 vaccination (shown above), his day improves substantially.

vaccinations: they are available at no cost in the US; pregnant individuals are advised to discuss vaccine options with their healthcare provider; and those with compromised immune systems might require a third dose for protection against severe disease (see Fig. 4). Lastly, the third video detailed common side effects associated with the COVID-19 vaccine, which include symptoms like a sore arm, headache, fever, chills, body aches, and nausea (see Fig. 5). The placebo control video featured a fantasy creature on a journey to bring happiness to children (see Fig. 6), a video unrelated to COVID-19.

In contrast, the attention-placebo control group was shown a 4-min animated video emphasizing themes of hope, devoid of any health or COVID-19 vaccine-related content (SA_1_VH_R, 2022).

2.5. Outcomes

2.5.1. Knowledge (primary outcome)

One of the three primary outcomes of this study was to assess the effectiveness of the SAS intervention video in increasing vaccine-related knowledge. For the assessment, we utilized true/false knowledge questions that measured general vaccine knowledge ($\omega = 0.88$), COVID-19 vaccine recommendation knowledge ($\omega = 0.8$), and knowledge of COVID-19 vaccine side effects ($\omega = 0.61$). Please refer to Appendix 1 for the questionnaire.

2.5.2. Behavioral intent (primary outcome)

We utilized a list experiment design to evaluate behavioral intent to be vaccinated and their interest in obtaining and disseminating credible and evidence-based information about the COVID-19 vaccine (see Appendix 1 for the list experiment). The control group was shown four list items, while the treatment group was presented the same four list items plus one additional sensitive item relating to COVID-19 ($\alpha = 0.76$). Participants were asked how many of the items on the list they agreed with, without specifying which ones. The list items were designed to minimize ceiling and floor effects and were arranged randomly to avoid revealing the purpose of the list experiment and to eliminate order effects.

The list experiment is designed to address potential social desirability bias, particularly when questions relate to sensitive topics such as COVID-19. By asking participants to indicate the number of items they agree with, wherein the COVID-19-related item is embedded, participants do not directly respond to that specific item. As a result, participants might perceive that their specific stance on COVID-19 is not identifiable, reducing the fear of social judgment.

For the four non-COVID-19 items, the average selections would be consistent between the intervention and control groups. Since participants from all three arms are included in both list experiment groups, any intervention effect on choices for the non-COVID-19 items should be offset by the randomization. Consequently, if a discrepancy arises in the average number of items chosen between the list experiment groups, it is likely attributable to the COVID-19-related item.

2.5.3. Participant engagement (primary outcome)

Study participants in arms 2 and 3 were given the option to watch the intervention video (post-trial access to treatment) or end the study upon completion of the online RCT. The Gorilla platform recorded this response along with the time spent watching the video. Participants were informed that their decision would not affect their financial compensation.

2.5.4. Self-perceptions (secondary outcome)

All participants were asked to complete 6 question items assessing their perceptions of severity ($\alpha = 0.96$) and susceptibility ($\alpha = 0.75$), three items regarding response efficacy ($\alpha = 0.94$), three items concerning self-efficacy, ($\alpha = 0.84$), two items concerning attitude ($\alpha = 0.91$), and four items about social norms ($\alpha = 0.64$). Further, we assessed participants hope scores ($\alpha = 0.93$), optimism scores ($\alpha = 0.92$), and trust scores ($\alpha = 0.85$) (for further details see (Barteit et al., 2022)).

2.5.5. Sample size and randomization

We aimed for a target sample size of $n = 800$ participants. The Gorilla platform was responsible for assigning a predetermined number of participants to each study arm using a balanced randomization method: $n = 280$ participants were allocated to both arm 1 and arm 2, while $n = 279$ participants were assigned to arm 3. During the balanced randomization participants were assigned to each arm in a 1:1:1 ratio. Therefore, the method was random without replacement, resulting in experiment groups of slightly different sizes due to drop-outs.

2.6. Statistical methods

2.6.1. Demographics

We performed a descriptive analysis of respondents based on gender, age, education level, race/ethnicity, vaccination status, and political beliefs.

2.6.2. Knowledge (primary outcome)

We assessed the effectiveness of the SAS intervention video in enhancing knowledge about vaccinations across three knowledge dimensions (details provided in Appendix 2). For each dimension, we computed a knowledge score by totaling the correct responses on the knowledge questionnaire. Subsequently, we applied the Kruskal-Wallis Test and the Pairwise Wilcoxon Rank Sum Test to detect statistically

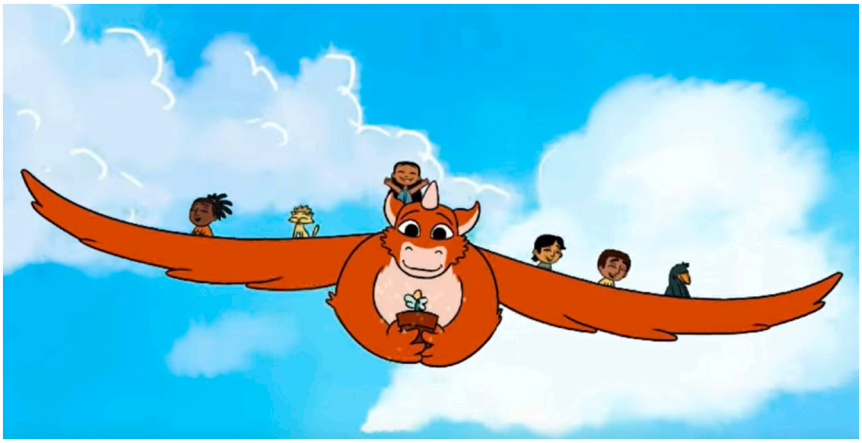


Fig. 6. SAS Attention Placebo Control video (arm 2) The video transports a message about hope as it shows a fantasy creature, which learns how to fly and subsequently collects children from their homes to bring them happiness.

significant differences in the average knowledge scores among the three study arms.

2.6.3. Behavioral intent (primary outcome)

We analyzed participants' behavioral intent towards COVID-19 vaccination by calculating and comparing the average differences in scores between the treatment (which included the sensitive item) and control groups. The treatment list group had a higher total score due to the additional (sensitive) question item. Thus, the difference in mean scores between the groups represents their difference in behavioral intent, indicating the intervention's effectiveness. We assessed the overall effect of the intervention by comparing the difference in average scores between arm 1 and arm 3. To estimate the content effect, we compared the average scores between arm 1 and arm 2. Here, "content effect" specifically refers to the nature of the video content, which includes COVID-19-related information in arm 1 and lacks such information in arm 2.

2.6.4. Participant engagement (primary outcome)

To evaluate participant engagement, we employed multivariable logistic regression to analyze the association between sociodemographic variables and the choice to watch the intervention video post-trial. Additionally, we applied multivariable linear regression, specifically the ordinary least squares (OLS) method, to investigate the relationship between the duration of time participants spent viewing the video and their sociodemographic characteristics.

2.6.5. Participants self-perceptions (secondary outcomes)

First, we computed scores for participants' perception of vaccine risks and benefits, attitude, self-efficacy, perceived social norms, and trust. Second, we used an OLS linear regression that examined potential correlations between participants' study arm and their secondary outcome scores.

Subsequently, we utilized multivariable logistic regression to assess the relationship between these scores and the vaccination status of participants. In this context, vaccination status was used as a proxy for vaccine hesitancy, with a greater number of vaccinations suggesting less hesitancy. As the secondary outcomes were measured post-intervention, there was potential for the intervention itself to act as a confounding variable. To address this, we exclusively analyzed data from participants in the non-intervention group (Arm 3), who were not exposed to the intervention. This approach allowed us to evaluate the secondary outcomes alongside the sociodemographic variables, ensuring that these measures were captured at baseline and free from intervention bias. In our analysis, we considered *P*-values below 0.05 to indicate statistical significance.

2.6.6. False discovery rate correction

For multiple hypothesis testing, we implemented a false discovery rate (FDR) correction to adjust the P-values. FDR correction was employed as an alternative to the more conservative Bonferroni correction, with the advantage of increasing statistical power by allowing for a controlled proportion of false positives. This approach is especially suitable for exploratory analyses where the balance between Type I and Type II errors is a consideration. The FDR correction was applied using the Benjamini-Hochberg procedure, a common method for controlling the false discovery rate in statistical data analysis.

2.7. Ethical considerations

Ethics approval for this study was granted by the Ethical Board of the Medical Faculty of the University of Heidelberg on May 3, 2022 (No. S-163/2022). Participants were required to provide digital informed consent to participate in the study. They were also informed that they could withdraw from the study at any time. For secondary analyses of research data, it was stated that the original informed consent (or the IRB) allows the secondary analysis without additional consent. The Gorilla platform collected participants' responses anonymously, ensuring that researchers could not trace participants' identities in any way. Data were de-identified to protect the privacy and confidentiality of the participants. Participants were compensated for their time in the study with £1.70 in British Pound. This compensation was provided as an acknowledgment of their contribution to the research and to encourage participation.

3. Results

3.1. Demographics

We recruited a total of 847 study participants from the US on May 31, 2022 (refer to Fig. 2 for details). Out of these, 792 participants (93.51 % of the recruited sample) completed the trial and were included in the final analysis (see Table 1 for participant characteristics).

Of all participants, 57.4 % ($n = 455$) identified as female, 40.8 % ($n = 323$) as male, and 1.8 % ($n = 14$) as other. Participants' age ranged from 18 to older than 65, with the majority (53.2 %; $n = 421$) being between 25 and 44 years old. Education levels varied from 13.5 %($n = 107$) having received high school education or less to 17.7 % ($n = 140$) holding a master's degree or higher, with the majority (37.6 %; $n = 298$) possessing a bachelor's degree. Most participants were White or Caucasian, accounting for 80.4 % ($n = 637$). Politically, participants ranged from extreme left (20.2 %; $n = 160$) to right of center (22.6 %; $n = 179$).

A total of 20.3 % ($n = 161$) of participants were not vaccinated, 4.9 % ($n = 39$) were vaccinated one time, 24.1 % ($n = 191$) two times, 43.8 % ($n = 347$) three times, and 6.8 % ($n = 54$) more than three times. Of all participants, 26,4 % ($n = 208$) have been tested positive on COVID-19 before and 64,7 % ($n = 509$) have not. At the outset, we included three exploratory questions to gauge participants' preliminary concerns about the potential risks posed by COVID-19. A majority of respondents ($n = 444$; 56 %) indicated they were not significantly worried about the health threats or mortality risks associated with COVID-19 (see Fig. 7). A smaller subset of participants ($n = 206$; 26 %) expressed concern, while the smallest group ($n = 142$; 18 %) remained neutral.

All participants of the intervention arm answered the attention question correctly. Of the attention placebo control arm 98.1 % ($n = 259$) answered the attention question correctly.

3.2. Knowledge assessment

The knowledge assessment's factor analysis yielded three distinct scales: General Vaccine Knowledge, COVID-19 Vaccine Recommendation Knowledge, and COVID-19 Vaccine Side Effect Knowledge, as depicted in Figs. 8 to 10. Subsequent between-arm comparisons using the Kruskal-Wallis Test indicated a significant effect of group assignment on knowledge scores across all three factors—factor 1 ($P = .002$), factor 2 ($P < .001$), and factor 3 ($P < .001$). Notably, the intervention group consistently exhibited higher knowledge scores compared to both the placebo control and the control groups. No significant difference was observed in knowledge scores between the attention placebo control group and the control group. Detailed results are presented in Table 2.

3.3. Behavioral intent

We evaluated the effect of the SAS videos on behavioral intent towards the COVID-19 vaccine in each study arm. As an example, in the intervention arm (study arm 1), the mean score for educational characteristics (list 1) in the treatment list group was 1.56, compared to 1.24 in the control list group. This difference of 32.6 % in behavioral intent ($1.56–1.24 \times 100$) reflects the prevalence of the sensitive item. By the same token, the prevalence of the sensitive item in list 1 was 16.5 % in the APC group and 35.4 % in the control group. The difference in

Table 1
Overview of participant demographics.

	Intervention (study arm 1), n	Intervention, (study arm 1), %	Placebo control (study arm 2), n	Placebo control (study arm 2), %	Control (study arm 3), n	Control (study arm 3), %
Gender						
Female	146	57.3 %	152	57.6 %	157	57.5 %
Male	107	42.0 %	107	40.5 %	109	39.9 %
Other	2	0.8 %	5	1.9 %	7	2.6 %
Age (year)						
18–24	26	10.2 %	24	9.1 %	30	11.0 %
25–34	67	26.3 %	70	26.5 %	76	27.8 %
35–44	75	29.4 %	69	26.1 %	64	23.4 %
45–54	34	13.3 %	51	19.3 %	44	16.1 %
55–64	37	14.5 %	35	13.3 %	37	13.6 %
65 or older	16	6.3 %	15	5.7 %	22	8.1 %
Education						
Completed high school or less	32	12.5 %	44	16.7 %	41	15 %
Some college but no degree	51	20.0 %	49	18.6 %	55	20.1 %
Associate degree	22	8.6 %	27	10.2 %	33	12.1 %
Bachelor's degree	101	39.6 %	106	40.2 %	91	33.3 %
Master's degree or higher	49	19.2 %	38	14.4 %	53	19.4 %
Ethnicity						
Asian or Pacific Islander	10	3.9 %	14	5.3 %	11	4.0 %
Black or African American	17	6.7 %	24	9.1 %	18	6.6 %
White or Caucasian	204	80.0 %	206	78.0 %	227	83.2 %
Other	24	9.4 %	20	7.6 %	17 %	6.2
Political beliefs						
Strongly Left Wing	50	19.6 %	51	19.3 %	59	21.6 %
Left Wing	56	22.0 %	64	24.2 %	64	23.4 %
Centre Left	39	15.3 %	34	12.9 %	34	12.5 %
Centre	61	23.9 %	49	18.6 %	52	19.0 %
Right of Centre	49	19.2 %	66	25 %	64	23.4 %
Total	255	100.0 %	264	100.0 %	273	100.0 %

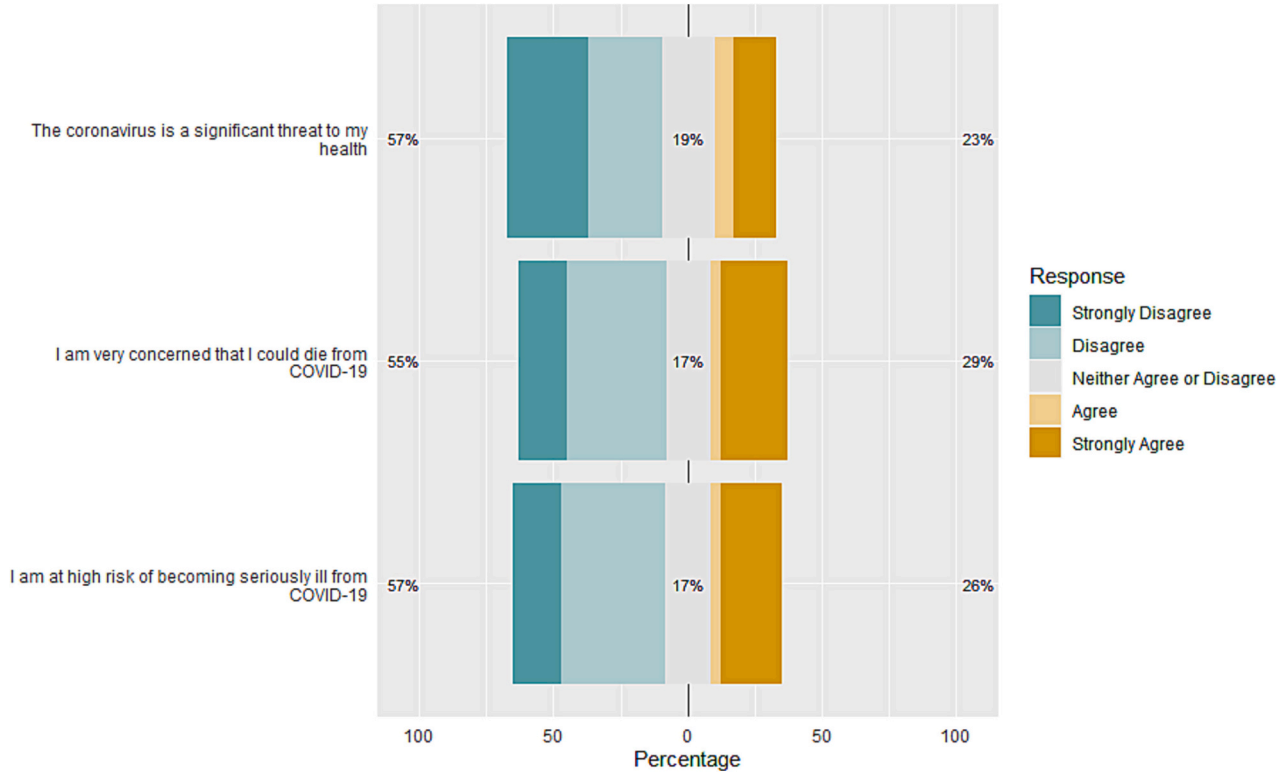


Fig. 7. Participants provided responses to three general questions regarding their level of concern about COVID-19.

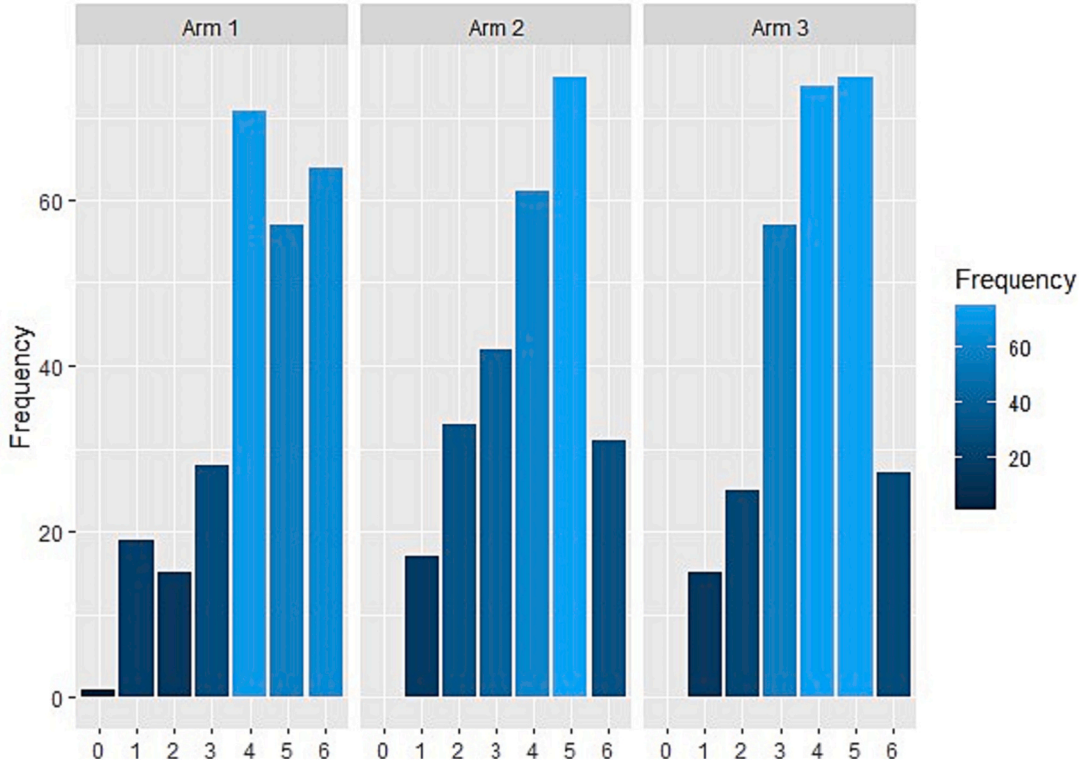


Fig. 8. Overview of participants' knowledge scores of Factor 1 (General Vaccine Knowledge) in the three different study arms.

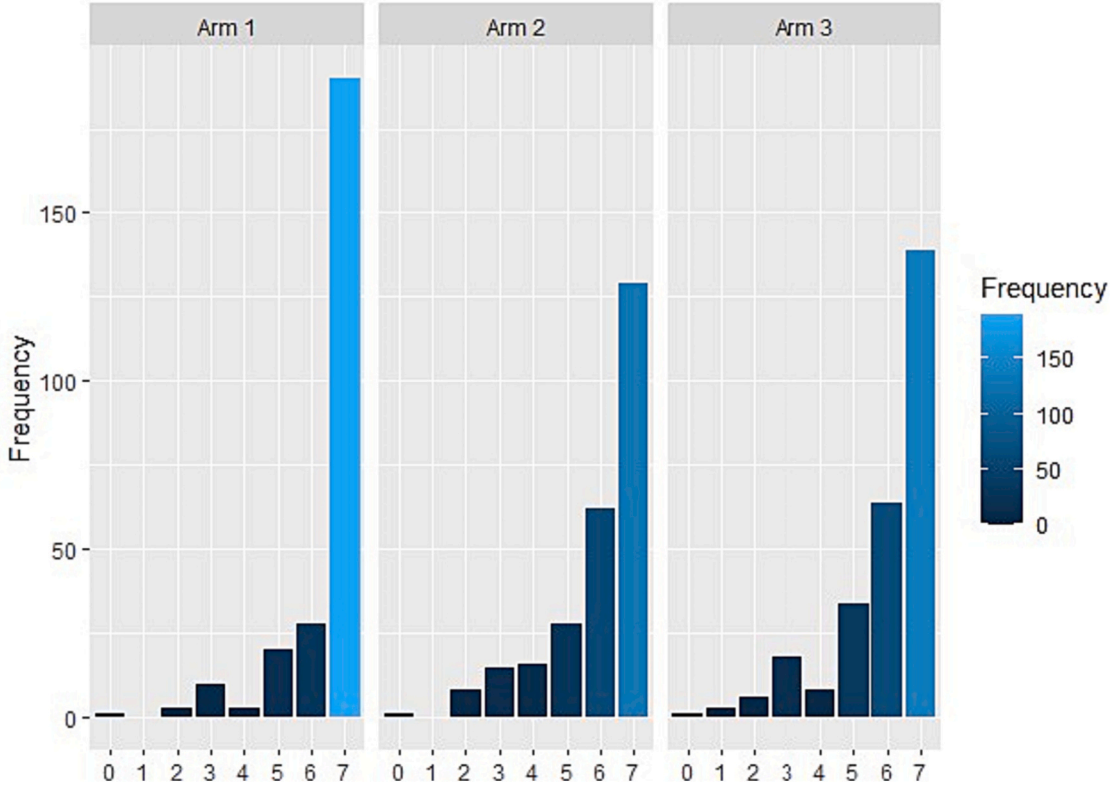


Fig. 9. Overview of participants' knowledge scores of Factor 2 (COVID-19 Vaccine Recommendation Knowledge) in the three study arms.

prevalence between arm 1 and 3 represents the content effect (16.18) and between arm 1 and 2 the intervention impact (−2.76). Overall, the results demonstrated no statistically significant differences between the study arms (for detailed results see Appendix 3).

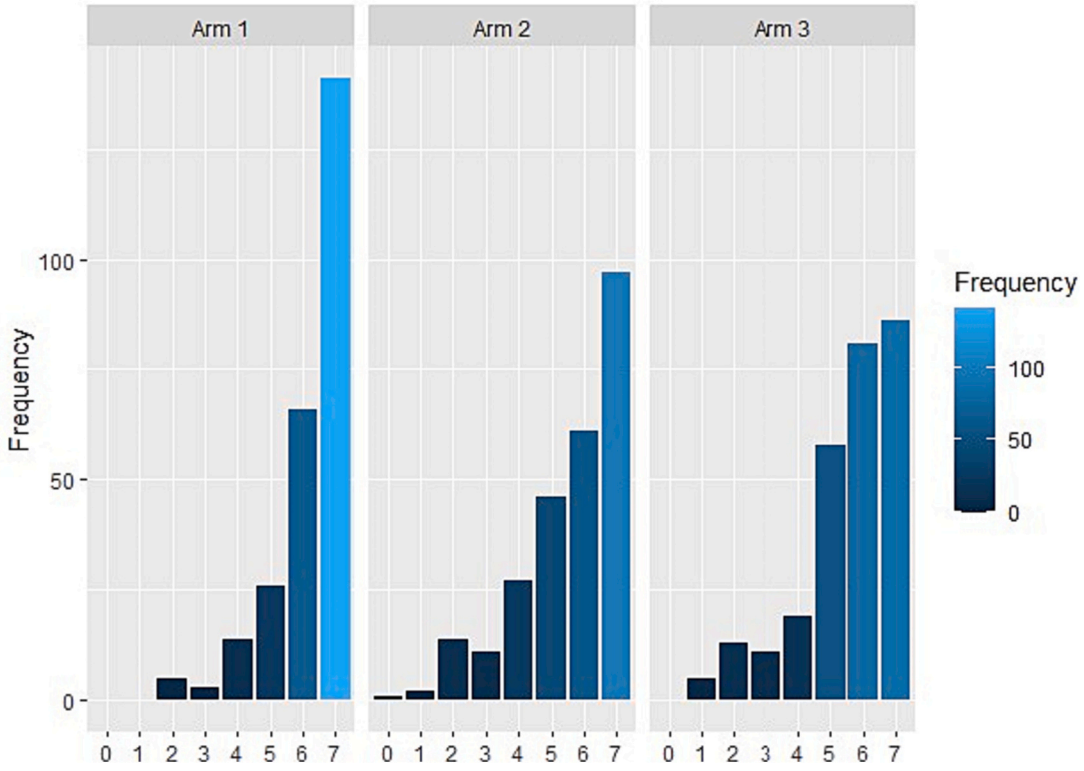


Fig. 10. Overview of participants' knowledge scores of Factor 3 (COVID_19 Vaccine Side Effects Knowledge) in the three study arms.

Table 2
Between group comparisons.

Factors	Groups compared	*P*
Factor 1: General Vaccine Knowledge	Arm 1 – Arm 2	0.011
	Arm 1 – Arm 3	0.002
	Arm 2 – Arm 3	1
Factor 2: COVID-19 Vaccine Recommendation Knowledge	Arm 1 – Arm 2	<0.001
	Arm 1 – Arm 3	<0.001
	Arm 2 – Arm 3	1
Factor 3: COVID_19 Vaccine Side Effects Knowledge	Arm 1 – Arm 2	<0.001
	Arm 1 – Arm 3	<0.001
	Arm 2 – Arm 3	1

3.4. Participant engagement

Of all participants who took part in the experiment, 68 % had the choice to watch the video post-trial. Of those, 25 % chose to watch the video, and 75 % chose not to.

Logistic regression was used to analyze the relationship between ending the experiment early and participants sociodemographic factors. It was found that holding all other predictor variables constant, the odds of ending the experiment early decreased in participants who agreed with the statement "The coronavirus is a significant threat to my health" (OR 0.43, 95 % CI 0.2–0.96). In contrast, the odds of ending the experiment early (which equals not watching the SAS video collage post-trial) increased (OR 1.98, 95 % CI 3.9–1.01) if participants identified as right-wing (see Appendix 3 for detailed results).

Participants who opted to watch the video post-trial did so for an average of 140 s, with the overall length of the video being 222 s. The video was watched the longest by participants aged 35 to 44 ($R2 = 0.069$, $F5,129 = 1.92$, $P = .006$) (see Appendix 3 for detailed results).

3.5. Determinants of vaccine hesitancy

As a secondary objective, we evaluated factors such as perceived risk and benefit, attitude, self-efficacy, perceived social norms, and trust to determine if the intervention influenced study participants in terms of these factors. The intervention video impacted the assessed factors, particularly when compared to the placebo control arm. Participants in study arm 1 had significantly higher self-efficacy scores (OR = 0.43, 95 % CI [−0.24–1.09]), higher scores of perceived social norms (OR = 0.58, 95 % CI [0.1–1.06]), and higher response efficacy scores (OR = 0.17, 95 % CI [−0.82–1.16]) compared to participants in study arm 3. In comparison to study arm 2, we found a significantly higher self-efficacy score (OR = 0.47, 95 % CI [−0.2–1.14]).

In a second step, we assessed whether some of those factors were also determinants of vaccine hesitancy. Holding all other factors constant, the odds of having a higher vaccination status increased by 9 % (OR 1.09, 95 % CI 1.07–1.11) if participants had trust in government bodies, institutions, and health care providers; by 8 % (OR 1.08, 95 % CI 1.04–1.12) if the perceived susceptibility score towards COVID-19 infection was high; by 15 % (OR 1.15, 95 % CI 1.12–1.17) if the perceived response efficacy score of the COVID-19 vaccine was high; by 12 % (OR 1.12, 95 % CI 1.1–1.15) if the perceived severity score of the COVID-19 virus was high; by 16 % (OR 1.16, 95 % CI 1.12–1.2) if the self-efficacy score was high; by 15 % (OR 1.15, 95 % CI 1.01–1.31) if the attitude score towards the COVID-19 vaccine was high; and by 37 % (OR 1.37, 95 % CI 1.34–1.39) if participants held a strong perception that getting vaccinated is a social norm. Moreover, the odds of having a higher vaccination status increased by 65 % (OR 1.65, 95 % CI 1.27–2.03) if participants strongly agreed with the statement "The coronavirus is a significant threat to my health" and by 44 % (OR 1.44, 95 % CI 1.14–1.74) if participants self-identified as politically strong left-wing (see Appendix 3 for detailed results).

4. Discussion

4.1. Principal findings

In our online RCT, we evaluated the impact of SAS videos on knowledge, behavioral intent, and engagement with the COVID-19 vaccine. Our findings showed that participants who watched the SAS videos on COVID-19 demonstrated significantly higher knowledge scores compared to those who watched a video about hope or no video at all. However, we found no statistically significant relationship between the SAS videos and participants' behavioral intent. Engagement with the SAS videos on COVID-19 increased post-trial for participants who perceived COVID-19 as a health threat, while it decreased for those who identified as right-wing. Participants aged 35–44 showed the highest engagement with the videos. The intervention video notably improved scores in perceived response efficacy, perceived social norms, and perceived self-efficacy. Moreover, we identified trust in government bodies/institutions/health care providers, perceived susceptibility to COVID-19 infection, perceived response efficacy of the vaccine, self-efficacy, perceived social norms, and sociodemographic factors as key determinants of vaccine hesitancy.

4.2. Knowledge

The variable knowledge was comprised of three factors, being General Vaccine Knowledge, COVID-19 Vaccine Recommendations Knowledge and COVID-Vaccine Side Effects Knowledge. The intervention group exhibited substantial improvement in knowledge scores on all three knowledge factors after viewing the SAS video, demonstrating its effectiveness in imparting pertinent information. Notably, while all increases were statistically significant, the impact was more pronounced on the scales related to COVID-19 than on the general vaccine knowledge scale.

We crafted the video content to cover topics that would be mostly unfamiliar to the majority of participants while remaining accessible to those with less prior knowledge. Our results align with other studies, such as a meta-analytic study (Feeley et al., 2022), which revealed that SAS videos are highly effective in enhancing clinical knowledge. Additionally, our study reaffirms previous findings with a larger sample size, as earlier studies often had considerably smaller sample sizes, such as Kakinuma et al. (Kakinuma et al., 2011) with $n = 211$, and Meppelink et al. (Meppelink et al., 2015) with $n = 105$. It is important to note that there have been relatively few studies conducted on SAS videos, and there is a scarcity of literature specifically addressing public or global health. The majority of research has focused on improving traditional medical expertise, such as enhancing diabetic health literacy (Calderón et al., 2014).

4.3. Behavioral intent

In summary, the SAS videos did not significantly enhance behavioral intent. Regarding the relatively small sample size of this study, such an outcome was not improbable. However, the coming efficacy study is powered for this outcome and therefore expected to provide more insightful results. Moreover, a systematic review by Li et al. investigated various social media-based interventions aimed at promoting vaccination uptake (Li et al., 2022). The review highlighted the importance of dialogue-based social media interventions in modifying behavioral intent. Given that participants can more readily relate to the role of the dialogue partner in the SAS videos, the conversational aspect may contribute to an increase in behavioral intent. Moreover, Li et al. concluded that interventions that foster knowledge development frequently rely on the Health Belief Model, whereas those that modify behavioral intent are grounded in the Theory of Planned Behavior. As such, a multi-theory framework may be more appropriate for guiding the creation of multimedia content, such as a SAS video on COVID-19. Further research is necessary to identify optimal methods for designing and integrating multimedia content to boost behavioral intent, and to understand how these effects can be translated into effective public or global health interventions.

4.4. Participant engagement

At the end of the trial, we examined whether participants would voluntarily watch the SAS intervention video collage. Our findings indicated that participants concerned about contracting COVID-19 were more inclined to seek information about the virus and, consequently, more likely to watch the COVID-19 video collage. This observation is supported by previous research establishing a connection between health anxiety and increased online information-seeking (Baumgartner and Hartmann, 2011). In the context of COVID-19, health anxiety has also been associated with cyberchondria, a clinical phenomenon where compulsive online health-related information-seeking exacerbates anxiety about one's physical health (Jokic-Begic et al., 2020). As a result, it is unsurprising that participants in our study who expressed fear of COVID-19 were more inclined to use the informational resources provided. We found that participants least likely to watch the video post-trial identified as right-wing, a finding consistent with previous research (Haakonsen and Furnham, 2022; Cadeddu et al., 2020). Generally, participants aged between 35 and 44 demonstrated the most interest in watching the intervention SAS video post-trial. The youngest age cohort (18–24 years) showed less interest, which initially seems surprising but aligns with Favaretti et al.'s findings (Favaretti et al., 2022). One possible explanation is that trust in medicine increases among people in their 30s and older (Opel et al., 2011), and older individuals express less concern about vaccination side effects (Wu et al., 2017). The overlap between affinity for modern media and increased trust in vaccinations may explain the heightened engagement among participants aged 35 to 44 (Fietkiewicz et al., 2016).

At present, there is insufficient evidence to determine how participant engagement (intrinsic interest) may contribute to COVID-19 vaccine hesitancy, highlighting the need for further research in this area.

4.5. Determinants of vaccine hesitancy

Previous research demonstrated that individual factors may play a significant role in vaccine hesitancy. Gerretsen et al. (Gerretsen et al., 2021) observed that mistrust in vaccine benefits was a primary determinant of vaccine hesitancy, consistent with our findings that lower vaccination status correlates with lower perceived response efficacy towards the COVID-19 vaccine. Furthermore, Murphy et al. (Murphy et al., 2021) found that individuals less likely to get vaccinated against COVID-19 did not trust traditional or authoritative information sources, reflecting our findings that confidence in government authorities, organizations, and health care practitioners were predictors of vaccination status.

Another study discovered that descriptive norms, which reflect the perceived behaviors of others, were a indicative for vaccine hesitancy (Jaffe et al., 2022). In line with this, we found that exposure to negative social norms was a predictor of vaccine hesitancy. Additionally, our found association between perceived susceptibility and perceived severity with vaccine hesitancy was well-documented in previous research (Du et al., 2021; Hossain et al., 2021).

Participants in the intervention arm had significantly higher scores in perceived self-efficacy, perceived social norms, and perceived response efficacy, all determinants of vaccine hesitancy. Consequently, SAS videos may indirectly lower vaccine hesitancy by influencing these factors.

In addition to the individual factors mentioned above, we identified several sociodemographic factors that played a role in predicting vaccine hesitancy. Firstly, participants who self-identified as strongly left-wing were more likely to be vaccinated, aligning with previous studies

(Haakonsen and Furnham, 2022; Cadeddu et al., 2020). Secondly, a strong fear of COVID-19 predicted vaccination among study participants, replicating a result from earlier research (Willis et al., 2021). Lastly, participants who identified their gender as "other" were more likely to get vaccinated. Although gender has been frequently discussed in prior research - few studies have accounted for gender diversity. Future research should consider this aspect when designing studies to ensure inclusiveness.

4.6. Limitations

One limitation of our study is that participants were compensated £1.70 for approximately 12 min of their time, which may have influenced their motivation to participate. Moreover, participants had to be aware of platforms like Prolific, which offer opportunities to participate in online research studies. Prolific states on its website that participants were recruited via social media, flyer distribution on university campuses, and the Prolific referral scheme (ceased March 2019). Consequently, this may have resulted in an overrepresentation of technologically savvy individuals or those with higher educational backgrounds. To ensure clarity and comprehensibility in participants' responses, we exclusively incorporated native English speakers in our study sample. Consequently, individuals on Prolific who did not identify as native English speakers were excluded from participation. This exclusion inadvertently omitted crucial demographic groups, such as first-generation immigrants, from our study. Given the distinct experiences and perspectives of these groups, particularly concerning COVID-19 vaccinations, our findings might not encapsulate the full breadth of views within the broader US population. This limitation may impact the generalizability of our results.

Furthermore, our sample had a disproportionately small number of participants who identified as right-leaning on the political spectrum. As Prolific is relatively new, it is likely that the platform does not appeal to individuals with more conservative views. This limitation implies that our study results should be generalized to the entire US population with caution. For our secondary objective, we limited our analysis to data from experiment arm 3 to examine the correlation between secondary outcomes and vaccination status. This approach necessitates a cautious interpretation of the secondary outcomes due to the relatively limited statistical power of this analysis. We address this limitation in our forthcoming main paper, which includes a significantly larger participant cohort.

The sample size for this pilot study is not sufficiently large to confidently detect statistically significant results. Thus, while these preliminary findings provide insights, they should be interpreted with caution due to potential limitations in statistical power.

5. Conclusion

We evaluated SAS videos to determine their effect on knowledge, behavioral intent, and engagement with the COVID-19 vaccine. Our findings indicate that SAS videos can effectively improve COVID-19 vaccination knowledge, making them a valuable tool for modern public health communication. However, the SAS intervention video did not have a substantial direct effect on increasing behavioral intent towards the COVID-19 vaccine. Despite this, the intervention was correlated with increased self-efficacy, perceived social norms, and perceived response efficacy, all of which were linked to higher vaccination status. This suggests an indirect influence of SAS videos on participants' behavior, indicating that they could be employed to promote individual behaviors crucial for the health of the broader population.

Furthermore, study participants who identified as right-wing were least interested in viewing the SAS intervention video post-trial, while participants aged 35–44 who were worried about contracting COVID-19 were most interested. In real-world applications, it would be advisable to target populations with the respective characteristics for maximal effects. Our findings support the use of SAS videos as a tool for health promotion and contribute to the expanding body of literature aimed at improving public health interventions to reduce vaccine hesitancy.

SAS videos may be effective in making health information accessible, indirectly influencing behavior, and potentially working well on social media platforms. This combination of factors offers hope for modern public health communication strategies that can address the challenges posed by globalization and technological innovations. Further research is still needed to determine the reach and impact of SAS videos, particularly on social media platforms.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The research data as well as the code used for the analysis will be made available by the corresponding author upon request.

Acknowledgements

TB, MA, CF, VH and SB were responsible for the conceptualization and design of this work. CF, VH and FB developed the online study on the platform Gorilla, whereby TK, MA, and SB reviewed the online study design. FB analyzed the data with support of SB. FB drafted the original manuscript with significant contribution from SB; all authors contributed to the editing and revisions of the manuscript. The final manuscript was approved by all authors.

Funding

This study received no external funding. The funding for the study was intramural by the Heidelberg Institute of Global Health. For the publication fee we acknowledge financial support by Deutsche Forschungsgemeinschaft within the funding programme "Open Access Publikationskosten" as well as by Heidelberg University."

Appendices. Supplementary data

The link https://www.youtube.com/watch?v=J76k4QdMwMQ contains the videos related to Figs. 3, 4 and 5 and the link https://www.youtube.com/watch?v=YtdFUJerNFs contains the video related to Fig. 6. Supplementary data to this article can be found online at https://doi.org/10.1016/j.invent.2023.100694.

References

Armocida, B., Formenti, B., Ussai, S., Palestra, F., Missoni, E., 2020. The Italian health system and the COVID-19 challenge. Lancet Public Health 5, e253. https://doi.org/10.1016/S2468-2667(20)30074-8.

Barteit, S., Hachaturyan, V., Beleites, F., Kühn, T., Favaretti, C., Adam, M., Bärnighausen, T., 2022. The effect of a short, animated story-based video on COVID-19 vaccine hesitancy: a study protocol for an online randomized controlled trial. Front. Public Health 10, 939227. https://doi.org/10.3389/fpubh.2022.939227. PMID: 36081470; PMCID: PMC9448293. Aug 23.

Baumgartner, S.E., Hartmann, T., 2011. The role of health anxiety in online health information search. Cyberpsychol. Behav. Soc. Netw. 14, 613–618. https://doi.org/10.1089/cyber.2010.0425.

Cadeddu, C., Daugbjerg, S., Ricciardi, W., Rosano, A., 2020. Beliefs towards vaccination and trust in the scientific community in Italy. Vaccine 38, 6609–6617. https://doi.org/10.1016/j.vaccine.2020.07.076.

Calderón, J.L., Shaheen, M., Hays, R.D., Fleming, E.S., Norris, K.C., Baker, R.S., 2014. Improving diabetes health literacy by animation. Diabetes Educ. 40, 361–372. https://doi.org/10.1177/0145721714527518.

Chowdhury, N., Khalid, A., Turin, T.C., 2021. Understanding misinformation infodemic during public health emergencies due to large-scale disease outbreaks: a rapid review. Z Gesundh Wiss 1–21. https://doi.org/10.1007/s10389-021-01565-3.

Consort-Statement > CONSORT 2010 > Title n.d. http://www.consort-statement.org/checklists/view/32–consort-2010/66-title (accessed November 22, 2022).
Du, M., Tao, L., Liu, J., 2021. The association between risk perception and COVID-19 vaccine hesitancy for children among reproductive women in China: an online survey. Front. Med. 8.
Dubé, E., Laberge, C., Guay, M., Bramadat, P., Roy, R., Bettinger, J.A., 2013. Vaccine hesitancy. In: Human Vaccines & Immunotherapeutics, 9, pp. 1763–1773. https://doi.org/10.4161/hv.24657.
Favaretti, C., Adam, M., Greuel, M., Hachaturyan, V., Gates, J., Bärnighausen, T., et al., 2021. Participant engagement with a short, wordless, animated video on COVID-19 prevention: a multi-site randomized trial. Health Promot. Int., daab179 https://doi.org/10.1093/heapro/daab179.
Favaretti, C., Vandormael, A., Hachaturyan, V., Greuel, M., Gates, J., Bärnighausen, T., et al., 2022. Participant engagement and reactance to a short, animated video about added sugars: web-based randomized controlled trial. JMIR Public Health Surveill. 8, e29669 https://doi.org/10.2196/29669.
Feeley, T.H., Keller, M., Kayler, L., 2022. Using animated videos to increase patient knowledge: a meta-analytic review. Health Educ. Behav., 10901981221116792 https://doi.org/10.1177/10901981221116791.
Fietkiewicz, K.J., Lins, E., Baran, K.S., Stock, W.G., 2016. Inter-Generational Comparison of Social Media Use: Investigating the Online Behavior of Different Generational Cohorts. 2016 49th Hawaii International Conference on System Sciences (HICSS), pp. 3829–3838. https://doi.org/10.1109/HICSS.2016.477.
Gerretsen, P., Kim, J., Caravaggio, F., Quilty, L., Sanches, M., Wells, S., et al., 2021. Individual determinants of COVID-19 vaccine hesitancy. PloS One 16, e0258462. https://doi.org/10.1371/journal.pone.0258462.
Gorilla Experiment Builder. Gorilla n.d. https://app.gorilla.sc/ (accessed June 16, 2022).
Haakonsen, J.M.F., Furnham, A., 2022. COVID-19 vaccination: Conspiracy theories, demography, ideology, and personality disorders. Health Psychol. https://doi.org/10.1037/hea0001222. No Pagination Specified-No Pagination Specified.
Hossain, M.B., Alam, MdZ, Islam, MdS, Sultan, S., Faysal, MdM, Rima, S., et al., 2021. Health belief model, theory of planned behavior, or psychological antecedents: what predicts COVID-19 vaccine hesitancy better among the Bangladeshi adults? Front. Public Health 9.
Jaffe, A.E., Graupensperger, S., Blayney, J.A., Duckworth, J.C., Stappenbeck, C.A., 2022. The role of perceived social norms in college student vaccine hesitancy: implications for COVID-19 prevention strategies. Vaccine 40, 1888–1895. https://doi.org/10.1016/j.vaccine.2022.01.038.
Jensen, U.T., Ayers, S., Koskan, A.M., 2022. Video-based messages to reduce COVID-19 vaccine hesitancy and nudge vaccination intentions. PloS One 17, e0265736. https://doi.org/10.1371/journal.pone.0265736.
Jokic-Begic, N., Korajlija, A.L., Mikac, U., 2020. Cyberchondria in the age of COVID-19. PloS One 15, e0243704. https://doi.org/10.1371/journal.pone.0243704.
Kakinuma, A., Nagatani, H., Otake, H., Mizuno, J., Nakata, Y., 2011. The effects of short interactive animation video information on preanesthetic anxiety, knowledge, and interview time: a randomized controlled trial. Anesth. Analg. 112, 1314–1318. https://doi.org/10.1213/ANE.0b013e31820f8c18.
Li, L., Wood, C.E., Kostkova, P., 2022. Vaccine hesitancy and behavior change theory-based social media interventions: a systematic review. Transl. Behav. Med. 12, 243–272. https://doi.org/10.1093/tbm/ibab148.
Lubis, T.A., Gunardi, H., Herqutanto, Soedjatmiko S., Satari, H.I., Alatas, F.S., et al., 2022. Educational videos to address vaccine hesitancy in childhood immunization. Vaccine 40, 5965–5970. https://doi.org/10.1016/j.vaccine.2022.08.044.
Mendel-Van Alstyne, J.A., Nowak, G.J., Aikin, A.L., 2018. What is 'confidence' and what could affect it?: A qualitative study of mothers who are hesitant about vaccines. Vaccine 36 (44), 6464–6472. https://doi.org/10.1016/j.vaccine.2017.09.007. Epub 2017 Sep 9. PMID: 28899629. Oct 22.
Meppelink, C.S., van Weert, J.C., Haven, C.J., Smit, E.G., 2015. The effectiveness of health animations in audiences with different health literacy levels: an experimental study. J. Med. Internet Res. 17, e3979 https://doi.org/10.2196/jmir.3979.
Murphy, J., Vallières, F., Bentall, R.P., Shevlin, M., McBride, O., Hartman, T.K., et al., 2021. Psychological characteristics associated with COVID-19 vaccine hesitancy and resistance in Ireland and the United Kingdom. Nat. Commun. 12, 29. https://doi.org/10.1038/s41467-020-20226-9.
Opel, D.J., Taylor, J.A., Mangione-Smith, R., Solomon, C., Zhao, C., Catz, S., et al., 2011. Validity and reliability of a survey to identify vaccine-hesitant parents. Vaccine 29, 6598–6605. https://doi.org/10.1016/j.vaccine.2011.06.115.
Prolific · Quickly find research participants you can trust. n.d. https://www.prolific.co/ (accessed June 16, 2022).
SA_1_VH_R. 2022.
SA_2_VH. 2022.
Schillinger, D., Chittamuru, D., Ramírez, A.S., 2020. From "Infodemics" to health promotion: a novel framework for the role of social media in public health. Am. J. Public Health 110, 1393–1396. https://doi.org/10.2105/AJPH.2020.305746.
Vandormael, A., Adam, M., Greuel, M., Gates, J., Favaretti, C., Hachaturyan, V., et al., 2021. The effect of a wordless, animated, social media video intervention on COVID-19 prevention: online randomized controlled trial. JMIR Public Health Surveill. 7, e29060 https://doi.org/10.2196/29060.
Willis, D.E., Andersen, J.A., Bryant-Moore, K., Selig, J.P., Long, C.R., Felix, H.C., et al., 2021. COVID-19 vaccine hesitancy: race/ethnicity, trust, and fear. Clin. Transl. Sci. 14, 2200–2207. https://doi.org/10.1111/cts.13077.
Wu, S., Su, J., Yang, P., Zhang, H., Li, H., Chu, Y., et al., 2017. Factors associated with the uptake of seasonal influenza vaccination in older and younger adults: a large, population-based survey in Beijing, China. BMJ Open 7, e017459. https://doi.org/10.1136/bmjopen-2017-017459.
Zhu, P., Tatar, O., Griffin-Mathieu, G., Perez, S., Haward, B., Zimet, G., et al., 2022. The efficacy of a brief, altruism-eliciting video intervention in enhancing COVID-19 vaccination intentions among a population-based sample of younger adults: randomized controlled trial. JMIR Public Health Surveill. 8, e37328 https://doi.org/10.2196/37328.