Fact or fiction: An experiment on how information sources and message framing influence vaccine risk perception

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Abstract

In view of the growing disinformation about vaccines on social media since the beginning of the Covid-19 pandemic, effective communication strategies encouraging vaccine uptake are needed. We conducted an experiment through an online, preregistered survey to explore which types of information sources are more trusted by the population regarding the risks of the Covid-19 booster, and which types of message frames are more effective in influencing the perception of risks for children. We surveyed a representative sample composed of 1,800 Spaniards in June 2022. The two dependent variables were respondents' perceptions of (1) the Covid-19 booster vaccine effectiveness and (2) the safety of the Covid-19 vaccine for children. Participants were randomly exposed to different messaging regarding these vaccines, with different sources of information (scientific consensus, scientific dissensus, governmental, influencers and medical doctors), and different message framing (pro- and anti-vaccine storytelling and pro- and anti-vaccine scientific data). Additionally, some respondents who did not receive any messaging formed a control group. Our findings suggest that different information sources and frames can influence people's risk perception of vaccines. The source 'medical doctors' had a positive effect on risk perception of the Covid-19 booster vaccine ($p < 0.05$), and pro-vaccine messages, in the form of both storytelling and scientific expository frames, had a positive effect on respondents' risk perception of the vaccine for children ($p < 0.1$ and $p < 0.05$, respectively). On the one hand, male and older respondents rated booster vaccines as more effective than female and younger respondents. On the other hand, right-wing respondents believed vaccines are somewhat less safe for children than left-wing respondents. These findings might support the development of strategic communication in vaccination programmes by public health departments to improve immunization rates in the general population. The practical and theoretical implications are discussed.

Keywords

Health information; Vaccines; Vaccine hesitancy; Disinformation; Fake news; Social media; Social networks; Covid-19; Experiments; Surveys; Sources of information; Narratives; Expository message.

1. Introduction

Full vaccination against Covid-19 has been received by 85.9% of the Spanish population, and 55.7% of adults have received the first booster dose. In the case of childhood vaccination, 46% of children aged 5-12 years have been fully vaccinated (*Ministerio de Sanidad*, 2022). However, this coverage is not enough, according to the *Spanish Association of Paediatrics* (*AEP*, 2022). Vaccine hesitancy towards booster and child vaccination represents a challenge for Spanish public health departments, worsened by the fact that coverage rates, by age and by region, are not uniform (*Ministerio de Sanidad*, 2022).

Individuals with vaccine hesitancy are characterised by being unclear about whether they want to be vaccinated or may be completely unwilling to be vaccinated, even if they have access to the vaccine (**MacDonald**, 2015). Thus, the level of vaccine hesitancy is closely related to vaccine acceptance or refusal behaviour (**Larson** *et al.*, 2014). It is a complex phenomenon in which several factors play a role, including confidence in the efficacy of vaccines (**Thorpe** *et al.*, 2022) and risk perception. People's perception of risk does not necessarily represent the real risk. This is because perception is subjective and can influence decision-making in relation to vaccines (**Malecki**; **Keating**; **Safdar**, 2021).

According to **Allington** *et al*. (2023), in a study conducted in the UK, vaccine-hesitant individuals were found to have a strong reliance on social media for information and a weak dependence on traditional mass media (television, radio and press). Social media consumption has been steadily increasing, experiencing a significant surge, especially during the pandemic. In 2022, the number of users accounted for 58% of the global population, marking a 10% increase compared with the previous year (*We are Social*, 2022). Notably, social media played a prominent role during the pandemic, facilitating the spread of misinformation, disinformation, and conspiracy theories (**Sánchez-Duarte**; **Magallón-Rosa**, 2020). Misinformation refers to messages not intended to cause harm, while disinformation is deliberately produced to harm individuals, institutions, or countries. According to Das and Ahmed,

> "misinformation spreads on a lighter note, while disinformation destabilizes society by transforming consumers into active agents of interpretation and propagation" (**Das**; **Ahmed**, 2022, p. 10).

García-Marín (2020) highlights how news on social media during the pandemic often underwent modifications, presenting a blend of accurate and false information, manipulated context and misleading facts. Such content prevailed over entirely fabricated news, creating an environment of uncertainty and distrust.

Regarding preventive measures during the pandemic, exposure to misinformation had an adverse effect on attitudes and intentions toward mask usage, as demonstrated by **Mourali** and **Drake**'s (2022) research. However, the authors also found that prolonged exposure to false claims has led to less positive reactions to this measure. According to **Greene** and **Murphy** (2021), even if a person is exposed to fake news only once and the immediate effects may not appear significant, this singular exposure could still have consequences for their behaviour.

In addition, traditional mass media have produced a large amount of content to answer the needs of a society eager to understand what was happening around it (**Costa-Sánchez**; **López-García**, 2020). Although this return of the public to the media during the pandemic has reaffirmed its social value in times of crisis (**Casero-Ripollés**, 2020), vaccine-related news can be both a promoter of vaccination and a barrier to its acceptance when the message is negative (**Larson** *et al.*, 2014). Beyond this approach, previous studies highlight that the format of the message (personal narratives and/or presentation of statistics) may also exert some influence on people's perception of risk in relation to health issues (**Shelby**; **Ernst**, 2013; **Vandeberg** *et al.*, 2022; **Nan** *et al.*, 2015).

> Vaccine reluctance is a complex phenomenon involving several factors, including confidence in the efficacy of vaccines and risk perception, which can influence decision-making in relation to vaccines

In this context, both information sources and message format may have implications for the acceptability of Covid-19 vaccines. This study conducted two experiments with 1,800 residents in Spain and aimed to evaluate the influence on risk perception of

- the information source on the effectiveness of the Covid-19 booster vaccine, and
- message framing in conveying messages about the risk associated with childhood vaccination against Covid-19.

This objective was based on the following research questions:

RQ1: How can information sources influence public perception of the Covid-19 booster vaccine effectiveness?

RQ2: How can message framing influence public perception regarding the safety of the Covid-19 vaccine for children?

2. Literature review

2.1. Information sources and vaccine hesitancy

The sources that people use play an important role when the information they seek is health related. The relationship with sources is complex and dynamic. Throughout the pandemic, there was a noticeable surge in the volume of information disseminated through various channels, such as the media, social media, official institutions, health experts, as well as from close friends and family. Choosing one source or several is related to the level of trust that people place in them. In the case of the coronavirus pandemic, the tendency has been to look for a variety of information sources (**Sallam** *et al.*, 2021). On the other hand, several studies point to social media as one of the most used sources for Covid-19 and vaccine issues (**Al-Daghastani** *et al.*, 2021; **Baig** *et al.*, 2020; **Sulistyawati** *et al.*, 2021).

Previous studies have established a relationship between the information source and vaccine acceptance. **Park**, **Massey** and **Stimpson** (2021) compared people who rely more on media and government sources with those who rely on other sources and found that the latter perceived Covid-19 as a less serious risk and had less intention to get vaccinated. Moreover, individuals who relied on social media exhibited the lowest levels of Covid-19 risk perception and willingness to be vaccinated when compared to those who relied on health professionals.

Karabela, **Coşkun** and **Hoşgör** (2021) investigated the most trusted sources of information about vaccines and found that participants who were thinking about getting vaccinated trusted *YouTube*, and those who would not get vaccinated trusted *WhatsApp* groups. However, people that trusted the government and health professionals had more pro-vaccine attitudes. **Reno** *et al.* (2021) found similar results. Social media have increased vaccine hesitancy, whereas the opposite has happened with institutional sites. **Sallam** *et al.* (2021) also established a relationship between vaccine hesitancy and social media as the main information source about Covid-19 vaccines.

In addition, we should also consider the Spanish context which presents relevant events that may have influenced communication and vaccination against Covid-19. Firstly, it is crucial to consider how certain specific aspects pertaining to adhering to European-level instructions may have influenced communication strategies in Spain. The collective response of the European Union and the decisions made during the authorisation process for vaccine boosters and childhood vaccinations have been significant factors that demand effective communication to inform the public and foster trust among the population. Moreover, it is important to analyse the role of medical doctors as a source of information in this context. It is important to mention cases such as 'Doctors for the truth,' who spread disinformation and denialist theories. Another important context to consider is the trust in supranational institutions at the global level, such as the *World Health Organization* and European authorities who played an important role in the Covid-19 vaccination programmes. These cases could have impacted vaccine acceptance, as well as spread misperceptions and doubts in the public, hindering efforts to communicate and promote vaccination.

2.2. Message framing and risk perception

Previous experiments have investigated the perception of health-related risk and how different types of message framing can influence risk perception. In a mediatised society, these frames used to communicate may have implications for the understanding of the world or may exert some kind of influence on the audience (**Nan** *et al.*, 2015). For example, narratives such as storytelling (short or long) or use of testimonials and first-person accounts are considered more persuasive than other formats (**Dahlstrom**, 2010). Indeed, the biographical perspective considers how personal experiences are narrated (**Pfeiffer-Castellanos**, 2014). When the audience identifies themselves with the story, values and points of view, the story can help them to make decisions about an issue, stimulate a behaviour change, or encourage them to increase their interest in and attention to a certain issue (**Joubert**; **Davis**; **Metcalfe**, 2019). In the context of audience loss, the use of narratives in journalism has been seen as a key strategy due to its positive influence in engaging the audience. It should be noted that the use of this format in news is not free of dilemmas between objectivity and subjectivity, between what

> Previous studies highlight that, although this return of the public to the media during the pandemic has reaffirmed its social value in times of crisis, vaccine-related news can be both a promoter of vaccination and a barrier to its acceptance when the message is negative

is fact and what is fiction (**Van-Krieken**; **Sanders**, 2021). **Boyson**, **Zimmerman** and **Shoemaker** (2015), for example, found that exposure to news stories with a personal story had a greater influence on risk perception of antiretroviral therapy related to human immunodeficiency virus (HIV) than news stories that presented statistical data. In another study related to Human Papillomavirus

> " Choosing one source or several is related to the level of trust that people place on them, and, in the case of the coronavirus pandemic, the tendency has been to look for a variety of information sources "

(HPV), **Nan** *et al.* (2015), noted that participants indicated a higher risk of contracting HPV after being exposed to a hybrid type of message (statistical and narrative) relative to messages containing only statistical or storytelling framing. In addition, first-person storytelling led to a higher perceived risk of HPV than third-person text. Both types of framing had an indirect effect on the intention to be vaccinated against HPV.

In an experiment to determine whether message framing (storytelling versus expository) influences risk perception about childhood vaccination, **Vandeberg** *et al.* (2022) found that anti-vaccination storytelling could reduce risk perception towards vaccination, especially for those who had a certain level of vaccine hesitancy. The anti-vaccine movement has used this narrative framing to influence parents not to vaccinate their children while public health professionals build their messages with statistics and scientific facts, evidence-based data, and research. Perhaps these approaches are not enough and storytelling strategies beyond these employed resources should also be used (**Shelby**; **Ernst**, 2013). To fight against vaccine hesitancy during the Covid-19 pandemic, it is necessary to invest in effective communication to 'reduce doubt, promote confidence and increase acceptance' (**Thorpe** *et al.*, 2022). Similarly, **Dahlstrom** (2014) highlights the importance of incorporating storytelling into public science communication, as it is a persuasive tool that not only enhances public interest in the topic but also improves understanding of the content being conveyed.

3. Methodology

We conducted an original survey in Spain during June 2022. The survey was administered online (CAWI) to a sample of 1,800 respondents over 18 years old. The respondents were recruited through the company *AsuFieldwork* and completed the survey in exchange for a small monetary compensation. Gender, age, and regional quotas were established to ensure that the sample was representative of the Spanish population in these relevant sociodemographic characteristics. Our two dependent variables were respondents' perceptions of (1) the Covid-19 booster vaccine effectiveness and (2) the safety of the Covid-19 vaccine for children. We focused on citizens' evaluations of these two characteristics of vaccines for theoretical and practical reasons. Theoretically, vaccine effectiveness and vaccine safety are two relevant characteristics that can influence vaccine hesitancy. Second, in practical terms, booster shot effectiveness and vaccine safety for children were two important topics regarding Covid-19 after the initial phases of the vaccination campaigns. Every survey respondent had to provide an evaluation of these two issues on a 1–10 scale. However, before answering each question, most of the respondents were randomly exposed to different vaccine messages. Additionally, some respondents did not receive any messages, as they constituted the control group that was used as a benchmark to compare the effectiveness of each message framing type. All survey respondents participated in both experiments but, as each of the experiments focused on different elements of vaccines, we minimised the chances that the first set of messages (about booster shot effectiveness) could influence respondents' answers to the second question (vaccine safety for children).

Table 1 summarises the types of treatment options that were provided to respondents for each experiment (the exact wording of all the treatments and framing for the dependent variables are presented in the Appendix). Table 1 also features the average time that respondents took to answer the question.

Table 1. Types of treatments and average time of answering

Experiment	Treatment version	Respondents that received the treatment	Average time spent answering (in seconds)
1. Perceptions of booster shot effectiveness	Version 1 (Control group): No treatment (just the question about vaccine effectiveness)	300	14
	Version 2: Scientific community (with consensus)	299	19
	Version 3: Scientific community (with dissensus)	300	17
	Version 4: Government	301	21
	Version 5: Social media influencer	300	16
	Version 6: Medical doctors	300	13
2. Perceptions of vaccine safety for children	Version 1 (Control group): Neutral message about children vaccination campaign	359	11
	Version 2: Storytelling message opposed to vaccination	360	23
	Version 3: Data-based message opposed to vaccination	360	17
	Version 4: Storytelling message in favour of vaccination	360	25
	Version 5: Data-based message in favour of vaccination	361	19

The fact that the survey was conducted online is interesting for our experiment. On the one hand, in this context, less attention is paid than in a laboratory setting (**Mutz**, 2011, pp. 12-13), which would go against detecting any effect of the treatments. As argued by Mutz,

> "the distractions of everyday life can reduce the likelihood that a treatment will have an impact" (**Mutz**, 2011, p. 13).

On the other hand, however, an online survey that is answered via computers or smartphones takes place in a similar environment to that in which an important part of the population consumes information. Therefore, even if the treatments of the survey experiment are in some ways different to the actual messages received by citizens in traditional and social media, the context in which the messages are received is similar, which arguably increases the external validity of the experiment.

All respondents gave their permission to participate in the research, and the data were completely anonymised. To comply with ethical requirements, the project *PredCov* (Multi-source and multi-method prediction to support Covid-19 policy decision-making) in which this study was developed, had been approved by the *Ethics Committee* of *Madrid University Carlos III* under the CEI_22 protocol. At the end of the survey, the participants had access to a text related to the benefits of vaccination and the booster dose, as well as links to obtain more information on the subject. The research protocol was previously published in *AsPredicted* under code 97920.

Some authors argue that the most appropriate analysis of an experiment is the comparison of mean answers across treatment groups (**Mutz**, 2011). This amounts to checking to what extent the answers provided by the respondents vary depending on the message that they received before answering the question. If we detect statistically significant differences in the response of a group with respect to the control group, this would mean that the treatment had an effect on respondents' perceptions. In our case, as we were dealing with multiple experimental groups and dependent variables on a 10-point scale, we performed Mann-Whitney U tests (also known as Wilcoxon rank-sum tests). This test is the non-parametric counterpart of the t-test (it does not require a normal distribution of replies) and we used it because, as shown, the distributions of replies were not normal and were skewed, as most respondents considered that Covid-19 vaccines were effective and safe.

With the Wilcoxon rank-sum test, we compared if the distributions of answers to different experimental versions were the same or different. Alternatively, this test could be interpreted as detecting differences in the median answers of each distribution. Secondly, we also fitted linear regression models that included relevant covariates. Although the randomisation of the survey messages already ensured that the effects found were related to the messages themselves and not due to other factors, the use of linear regressions as an additional analysis enabled us to incorporate and assess the effect of other factors on the evaluations of booster shot effectiveness and of vaccine safety for children.

4. Results

First, regarding the sociodemographic composition of our sample, in the tables 1 and 2 we can see that there was a similar proportion of males and females (Table 2). Additionally, all the Autonomous Communities (Spanish regional entities) were represented (Table 3). Finally, regarding age, we had a certain over-representation of younger respondents (Table 4), which was also related to the over-representation of more highly educated respondents in our sample.

Table 3. Participants' residence in Spain

Autonomous community	Freq.	Per cent
Andalucía	326	18.11
Aragón	50	2.78
Asturias	40	2.22
Islas Baleares	42	2.33
Islas Canarias	81	4.50
Cantabria	23	1.28
Castilla La Mancha	79	4.39
Castilla y León	94	5.22
Cataluña	294	16.33
Comunidad Valenciana	191	10.61
Extremadura	41	2.28
Galicia	105	5.83
La Rioja	13	0.72
Madrid	253	14.06
Murcia	58	3.22
Navarra	25	1.39
País Vasco	85	4.72
Total	1800	100

Table 2. Participants' gender

Sex	Freq.	Per cent
Female	911	50.61
Male	889	49.39
Total	1800	100

Table 4. Participants' age

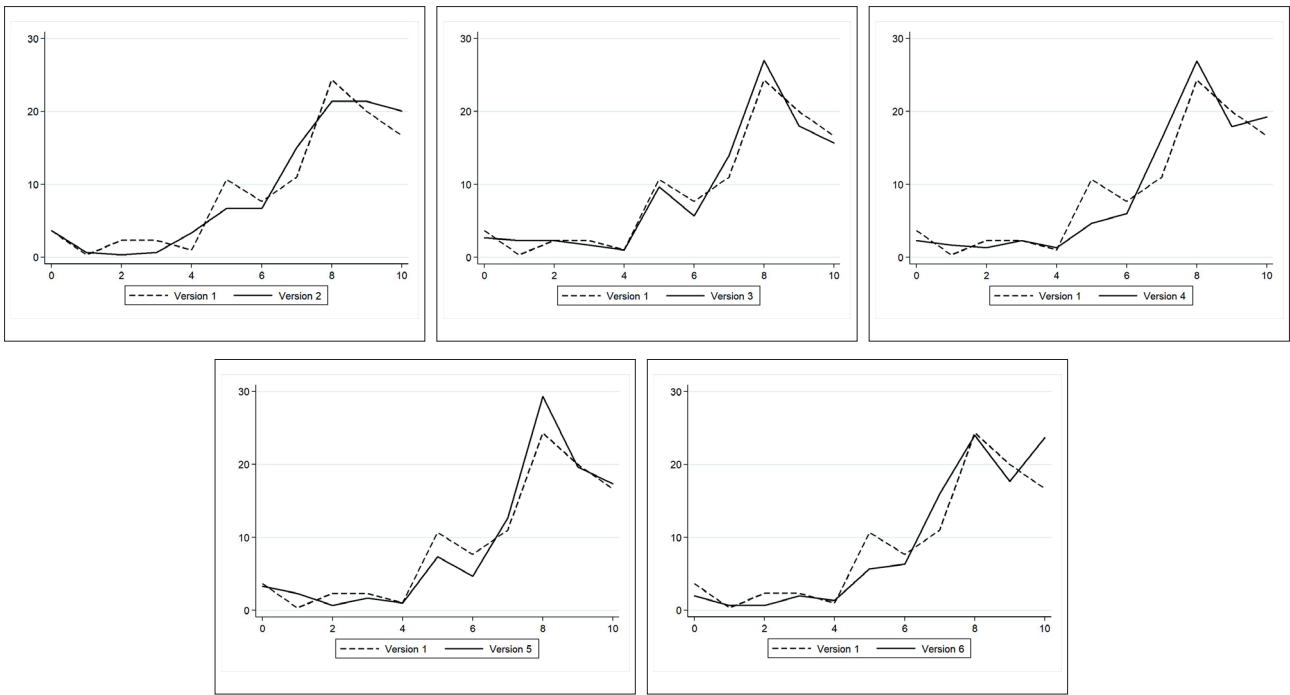| Age	Freq.	Per cent
18–24	200	11.11
25–34	293	16.28
35–44	390	21.67
45–54	368	20.44
55–64	279	15.50
65–74	193	10.72
More than 74	77	4.28
Total	1800	100

Figure 1. Information sources and perception regarding the Covid-19 booster vaccine effectiveness (by treatment group)

Concerning the answers to the experimental questions first, regarding the Covid-19 booster vaccine effectiveness (Figure 1), most respondents in all groups tended to consider the booster shots as effective or very effective (rating them with values higher than 5). In fact, the most common score across all groups was eight. Moreover, the answers of the groups that received messages were quite similar to the control group (Version 1, which only received the question without a previous message), which implies that the experimental messages were not significantly effective. The comparison between Version 1 and the other versions can be seen in the different panels of Figure 1. However, respondents that received Version 6 (the message with 'medical doctors' as sources) tended to value the booster shots more positively. In particular, they rated the booster shots with the maximum score to a greater extent than the control group (and the other groups).

Respondents' perceptions about the Covid-19 vaccine safety for children were also predominantly positive, as shown in Figure 2. However, in this case, there were higher proportions of respondents who considered that Covid-19 vaccines were not safe for children. Additionally, the patterns of answers are similar across groups, but Versions 5 and 6 (the ones with pro-vaccination messages) showed a higher proportion of maximum scores than the control group (Version 1). This implies that the respondents who received these versions tended to value vaccine safety for children more than the respondents that received a neutral message (control group).

As shown in Table 5, the first experiment indicated that there was no statistically significant difference between the control group and the first four treatments, but the answers of those who received a message in which the source were 'medical doctors' were different to the answers of the control group at a statistically significant level (p < 0.05).
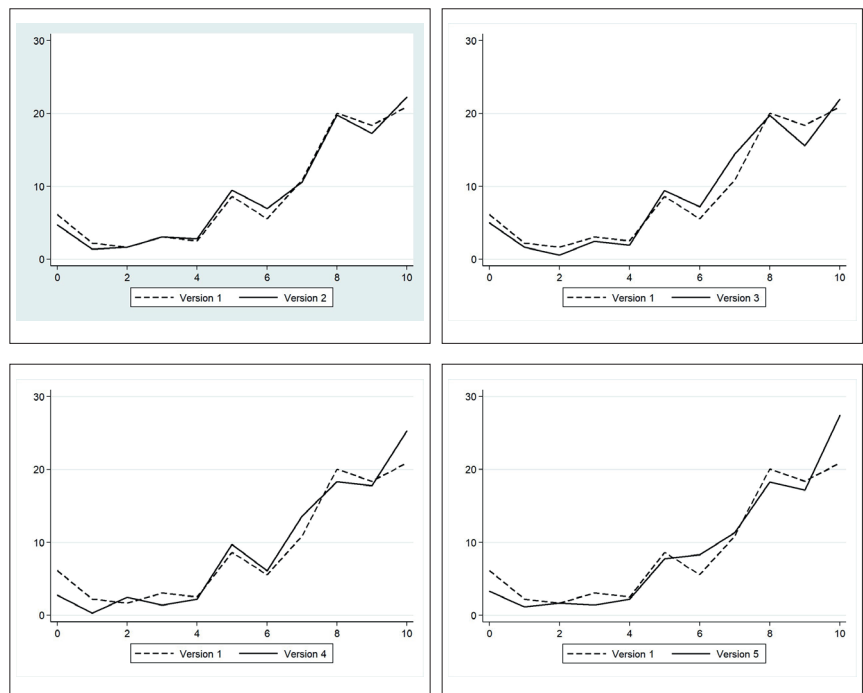

Figure 2. Message framing and perception of the Covid-19 vaccine safety for children (by treatment group)

Table 6 shows the results of the second experiment. We found that pro-vaccine messages (both storytelling and scientific messages) influenced respondents if we compared their answers with those of the control group that received a neutral message about child vaccination. In the case of pro-vaccine storytelling, there was a difference with respect to the control group with a 90% level of confidence (p < 0.1), while there was a difference between Group 5 (pro-vaccine scientific message) and the control group with a 95% level of confidence (p < 0.05).

The regression models (Table 7) align with the previous analysis. In the first experiment (Model 1), only the treatment that mentioned medical doctors (Version 6) had an influence on respondents' attitudes towards booster shot effectiveness. More specifically, this treatment resulted in 0.41 points increase in respondents' perceptions of vaccine effectiveness on a 1–10 scale, compared with the control group (which would be Version 1, the reference category).

Besides the effect of the experimental treatments, the regression coefficients also showed that males and older respondents regarded booster shots as more effective than females and younger respondents while holding the rest of the factors fixed (**Wooldridge**, 2016, p. 61). More specifically, males considered that booster shots were 0.23 points more effective, on average than females (on the 1–10 scale). Regarding the effect of age, the 0.006 coefficient means that, for instance, a difference of 45 years of age (between a 20-year-old and a 65-year-old individual) was associated with a 0.29 points more positive evaluation of booster shots. On the other hand, the educational level and ideology did not appear to be associated with attitudes towards booster shots in a statistically significant way.

Regarding the second experiment, we again saw an effect of pro-vaccine messages, both in the form of storytelling and scientific data message framing. This aligns with the results of the previous analysis (i.e. the comparison of each of the experimental groups' answers via Wilcoxon rank-sum tests). The effects of storytelling and scientific data framing were slightly higher than the effect of Version 6 of Experiment 1, and similar to each other. In addition, age was associated with more positive evaluations of vaccine safety. In this case, the difference between a 20-year-old and a 65-year-old individual was that the latter made evalua-

Table 5. Booster shot effectiveness

Experiment 1 (Pairwise comparisons)	p-value
Control and Group 2 (scientific consensus)	0.172
Control and Group 3 (scientific dissensus)	0.783
Control and Group 4 (government)	0.251
Control and Group 5 (influencers)	0.344
Control and Group 6 (medical doctors)	**0.029****

Table 6. Vaccine safety for children

Experiment 2 (Pairwise comparisons)	p-value
Control and Group 2 (anti-vaccine storytelling)	0.739
Control and Group 3 (anti-vaccine scientific data)	0.872
Control and Group 4 (pro-vaccine storytelling)	0.093 *
Control and Group 5 (pro-vaccine scientific data)	**0.036****

Table 7. Results of the regression models

Variables	Model 1 first experiment	Model 2 second experiment
Experiment (ref: Version 1)		
Version 2	0.246	0.133
	(0.190)	(0.194)
Version 3	−0.0206	0.165
	(0.190)	(0.194)
Version 4	0.254	0.505***
	(0.189)	(0.194)
Version 5	0.219	0.483**
	(0.190)	(0.194)
Version 6	0.421**	
	(0.190)	
Age	0.00638*	0.00742*
	(0.00358)	(0.00400)
Sex	0.230**	0.418***
	(0.112)	(0.126)
Educational level (ref: Primary studies)		
Lower secondary (ESO)	−0.250	−0.550
	(0.368)	(0.412)
Upper secondary (Bachillerato)	0.460	0.273
	(0.344)	(0.385)
Vocational training (Middle)	−0.0573	−0.287
	(0.362)	(0.406)
Vocational training (Upper)	0.0951	−0.321
	(0.349)	(0.391)
Tertiary studies	0.460	0.103
	(0.330)	(0.369)
Other studies	−0.0889	−0.877
	(0.768)	(0.861)
Ideology	−0.0330	−0.0548**
	(0.0231)	(0.0259)
Constant	6.840***	6.897***
	(0.412)	(0.465)
Observations	1,800	1,799
R-squared	0.024	0.030

Notes: Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1

tions that were 0.33 points more positive, on average, than the former. According to the model results, males made evaluations 0.48 points more positive than females. Ideology appears to be related to the perception of vaccine safety for children; more right-wing respondents regarded vaccines as slightly less safe for children than left-wing respondents. More specifically, a unit increase in the ideology scale (that is, having a more right-wing ideology) decreased the evaluation of vaccine safety for children by 0.05 points on the 1–10 scale. Note, however, that the effect was quite small. According to this regression coefficient, a nine-point difference in ideology (which is the same as going from extreme left to extreme right) resulted in a 0.45-point decrease in the evaluation of vaccine safety for children.

> Our experiment on disinformation and vaccines suggests that different narratives can influence people's trust and acceptance

In sum, it is important to note that the experimental treatments had a slightly greater effect than the other predictive factors (age, gender, and ideology) on respondents' evaluations.

5. Discussion

Our experiment on disinformation and vaccines suggests that different information sources and narratives can influence people's trust in and acceptance of vaccines. The first experiment found that only the message from medical doctors influenced respondents' perceptions of the booster vaccine's effectiveness. The second experiment showed that pro-vaccine messages, both in the form of storytelling and scientific data message framing, had a positive effect on respondents' attitudes toward children's vaccine safety. These findings suggest that the source of the message is an important factor in influencing vaccine acceptance, with messages from medical doctors being particularly effective. Moreover, pro-vaccine messages can be effective in increasing vaccine acceptance. Furthermore, males and older respondents rated booster vaccines as more effective than females and younger respondents, while education level had no influence on the perception of the Covid-19 booster dosage. On the other hand, right-wing respondents believed vaccinations are somewhat less safe for children than left-wing respondents. These findings have further relevance as research suggests that exposure to disinformation and various narratives might influence people's trust and acceptance of vaccines. Studies have found that distrust in vaccines, mistrust in government and conspiracy beliefs can increase vaccine hesitancy (**Jennings** *et al.*, 2021). Additionally, exposure to Covid-19 vaccine misinformation on social media has been shown to impact vaccine acceptance (**Cascini** *et al.*, 2022; **Loomba** *et al.*, 2021).

The source of the message is an important factor in influencing vaccine acceptance, with messages from health professionals being particularly effective (**Motta** *et al.*, 2021; *Unicef*, 2020). Our results are in agreement with a recent publication in Nature (**Bartoš** *et al.*, 2022) that found that only the message from medical doctors influenced respondents' perceptions of booster vaccine effectiveness. That study found that communicating doctors' consensus persistently increases vaccine uptake, especially among those who underestimated doctors' trust and vaccination recommendations. Indeed, health professionals and public health experts hoping to encourage vaccination may be effective by appealing to personal and collective health risks, or the economic imperatives of vaccinating. This is because a key factor in gaining acceptance of a new vaccine is trust (*AAFP*, 2021). Media disinformation can cause public doubts about disease spread, prevention, lethality, and vaccine safety, and can promote mistrust of the government, policymakers, health authorities and pharmaceutical companies. Direct messaging from other health-care workers (HCWs), whether in the capacity of a personal physician or co-worker, may be especially effective in decreasing vaccine hesitancy. The population generally has a high level of trust in their physician (*AAFP*, 2021). Confidence among HCWs can be heightened through discussion, eliciting their concerns and involving them in vaccine recommendations. Indeed, the *Vaccine Messaging Guide* by *Unicef* (2020) suggests that credible communicators are essential for building trust with the audience. Health-care professionals are among the most trusted sources of health information and provider recommendations of vaccination significantly increase vaccine uptake. This makes them excellent messengers about vaccination, especially if they vaccinate themselves and their children. However, **Motta** *et al.* (2021) found that messages originating from expert sources are not necessarily less effective than messages from ordinary citizens, which are also effective at increasing intended vaccine uptake. Here we can see that both health professionals and ordinary people sharing positive stories about vaccines may be good allies in increasing vaccine uptake.

Another important factor influencing vaccine acceptance is message framing, i.e. storytelling or scientific data message framing. In this regard, our results are well aligned with previous studies which demonstrated that when presented alone, statistical information supplied by an expert (i.e. the science-supporting message) on vaccine safety and efficacy resulted in higher pro-vaccine attitudes than the control neutral message (**Kuru** *et al.*, 2021). However, while pro-vaccine messages can have a positive effect on respondents' attitudes toward children's vaccine safety, their effectiveness may vary depending on existing parental attitudes toward vaccines. For some parents, pro-vaccine messages may increase misperceptions or reduce vaccination intention (**Nyhan** *et al.*, 2014). Therefore, it is crucial that public health messages on vaccines be evaluated before being distributed to determine their effectiveness, particularly among resistant or sceptical parents.

> The source of the message is an important factor in influencing vaccine acceptance, with messages from medical doctors being particularly effective

The regression coefficients also showed that males and older respondents were more likely to perceive vaccines as effective, while ideology was related to the perception of vaccine safety for children. Similar research also found that males and older respondents were more likely to perceive vaccines as effective (**El-Mohandes** *et al.*, 2021; **Lindholt** *et al.*, 2021). Specifically, females have a five percentage point lower acceptance of an approved vaccine compared with males (**Lindholt** *et al.*, 2021). Unwillingness to vaccinate was significantly lower among respondents age 60 and older compared to younger respondents (**El-Mohandes** *et al.*, 2021). In addition, ideology was also noted in another study with similar findings in relation to the perception of vaccine safety for children, showing how conservative respondents are less likely to express pro-vaccine attitudes than liberal respondents (**Baumgaertner**; **Carlisle**; **Justwan**, 2018). These findings suggest that public health campaigns aimed at increasing vaccine acceptance may need to consider demographic and ideological factors in addition to the source and content of the message. In relation to these findings, a previous study (**Jensen**; **Ayers**; **Koskan**, 2022) was also aligned with our study showing that:

> Males and older respondents rate booster vaccines as more effective than women and younger respondents, while education level had no influence on the perception of the Covid-19 booster dosage

- males and older respondents were more likely to perceive vaccines as effective;
- ideology was related to the perception of vaccine safety for children (parents expressing conservative ideology were less likely to vaccinate their children against Covid-19);
- concerns about the vaccine's long-term side effects were uniquely associated with an increased likelihood of parents being unsure about vaccinating their children compared to positive vaccine intention.

However, in relation to political ideology, a recent study (**Rasul**; **Ahmed**, 2023) found that misinformation exposure increases Covid-19 vaccine hesitancy for conservatives and moderates but not for liberals. However, perceived misinformation exposure influences Covid-19 vaccine hesitancy among conservatives only if they are also 'flu vaccine-hesitant. This means, that ideology may produce a generalised vaccine hesitancy, not only against the Covid-19 vaccine.

We would like to declare some limitations that should be considered when interpreting the abovementioned results. First and foremost, the survey was self-administered, which does not guarantee that all respondents understood the questions or were totally honest in their responses. Second, our sample included a large proportion of university graduates, which focuses on a certain demographic and may have consequences for the results. Aside from that, the cross-sectional aspect of this study and the descriptive technique of the analysis should be highlighted. This limits us from proving the possible causal impacts of certain vaccine-related behaviours or attitudes in connection to sociodemographic characteristics, prior Covid-19 experience and usage of both conventional and social media. Future studies might use cross-tabulation analysis to investigate the association between these various factors. Moreover, regarding our first experiment, another factor that will likely moderate the effect of messages issued by different sources is the channel through which respondents receive those messages. Our design cannot assess the extent to which different channels will increase or decrease the effect of these messages, so this interaction will need to be explored in future analyses. Despite these limitations, these results highlight the importance of effective communication strategies in promoting vaccine acceptance, particularly in the face of disinformation and lack of scientific consensus, highlighting the responsibility of the media and institutions in communicating with the public during a health crisis (**Costa-Sánchez**; **López-García**, 2020). Our study might support the development of vaccination campaigns by public health departments as well as increase vaccination rates in the general population. Future research may need to investigate the long-term effectiveness of these strategies, as well as the effectiveness of interventions targeted at specific demographic and ideological groups. In addition, other lines of research may focus on: 1) comparing these results with those of other similar diseases, to develop more effective messages to encourage adult vaccination; and 2) an experiment to assess the effect of type of content (totally false, misleading message, manipulation of information) on people's behaviour towards vaccines.

> It is crucial that public health messages on vaccines be evaluated before being distributed to determine their effectiveness, particularly among resistant or sceptical parents

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7. Appendix

Original questions and messages used in the two experiments. For each experiment, we show the translated text in English. Participants allocated in the control group (V1) did not receive any message prior the question (experiment 1) or received a neutral message (experiment 2). The remaining participants read a vaccine-related message prior the question.

Table 1. Sources of information and the Covid-19 booster vaccine effectiveness (Experiment 1)

Control Group: Did not receive any prior message V1 Point out, according to you opinion, the effectiveness of Covid-19 booster shots in order to prevent hospitalizations:
Source: 'Scientific consensus' V2 There is scientific consensus in that the Covid-19 booster shot is very effective against the coronavirus variants. Point out, according to you opinion, the effectiveness of Covid-19 booster shots in order to prevent hospitalizations:
Source: 'Scientific dissensus' V3 Some scientific research shows that Covid-19 booster shots are very effective against coronavirus variants, while other research shows that booster shots are not very effective. Point out, according to you opinion, the effectiveness of Covid-19 booster shots in order to prevent hospitalizations:
Source: 'Governmental' V4 The Spanish Government has declared that Covid-19 booster shots are very effective against coronavirus variants. Point out, according to you opinion, the effectiveness of Covid-19 booster shots in order to prevent hospitalizations:
Source: 'Influencer' V5 A message by an Instagram influencer explaining that Covid-19 booster shots are very effective against coronavirus variants has gone viral. Point out, according to you opinion, the effectiveness of Covid-19 booster shots in order to prevent hospitalizations:
Source: 'Medical doctors' V6 Medical doctors have declared that the Covid-19 booster shot is very effective against coronavirus variants. Point out, according to you opinion, the effectiveness of Covid-19 booster shots in order to prevent hospitalizations:

Table 2. Message framing and the Covid-19 vaccine safety for children (Experiment 2)

Control Group: Neutral frame V1 Control group. Neutral message about children vaccination: The Covid-19 vaccination campaign continues this week, with the aim of vaccination children. In the afternoons, vaccination centres will receive children between 5-11 years of age. Point out to what extent do you agree with the following statement: "It is safe to vaccinate children":
Message frame: Anti-vaccine storytelling V2 Little Laura, of 7 years of age, can't stay still in the vaccination queue. Like the rest of the children, she doesn't want to be there. She would rather be at the park, playing with her friends. Her mother, María, also looks anxious with her arms crossed. She isn't sure if it is really necessary to vaccinate her daughter, she has read that the disease barely affects children. Her daughter was all right during the whole pandemic, why should she get the vaccine now? It doesn't make any sense. Her classmates haven't received the vaccine either. Perhaps she should leave without vaccinating her daughter. She grabs her by the hand and goes to the exit. She is sure that her daughter will continue to be all right, as always. Point out to what extent do you agree with the following statement: "It is safe to vaccinate children":
Message frame: Anti-vaccine scientific data V3 According to the latest epidemiological report by the *Carlos III Institute of Madri*d, children hospitalizations are rare and represent 0.78% of the overall hospitalizations since the beginning of the pandemic. Regarding deaths, seven children have passed away due to the Covid-19 during this period. The Spanish Society of Paediatric Infectiology considers that most children are safe against the effect of the pandemic, if compared with adults and older people. Point out to what extent do you agree with the following statement: "It is safe to vaccinate children":
Message frame: Pro-vaccine storytelling V4 Sara looks at the phone, she has received a message requiring her to go to the appointment to vaccinate Fernando this afternoon. Finally! She is relieved. She is always checking the news to see when the children vaccination campaign will start. She stops to think how this took so long… she was worried something bad could have happened to Fernando, but now she is more relaxed. She hugs her son, who is beside her in the couch. He has already suffered a lot due to his grandfather's death. We don't want this to happen also to Amelia, his grandmother. Point out to what extent do you agree with the following statement: "It is safe to vaccinate children":
Message frame: Pro-vaccine scientific data V5 The sixth wave has caused a lot of infections among children less than 12 years old, which now amounts to 13% of the cases. There are 393.394 cases since the beginning of the pandemic. Experts point out that even if children are less affected by hospitalizations and deaths, the vaccine will protect them against severe cases and deaths. Besides individual benefits, children vaccination will slow down cases of infections. Centres for Disease Control point that children vaccination will help stop the spread of the coronavirus towards "other people, even at home and at the school". Point out to what extent do you agree with the following statement: "It is safe to vaccinate children":