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Countering vaccine hesitancy through medical expert endorsement

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ABSTRACT

Scientists and medical experts are among the professionals trusted the most. Are they also the most suitable figures to convince the general public to get vaccinated? In a pre-registered experiment, we tested whether expert endorsement increases the effectiveness of debunking messages about COVID-19 vaccines. We monitored a sample of 2,277 people in Italy through a longitudinal study along the salient phases of the vaccination campaign. Participants received a series of messages endorsed by either medical researchers (experimental group) or by generic others (control). In order to minimise demand effects, we collected participants' responses always at ten days from the last debunking message. Whereas we did not find an increase in vaccination behaviour, we found that participants in the experimental group displayed higher intention to vaccinate, as well as more positive beliefs about the protectiveness of vaccines. The more debunking messages the participants received, the greater the increase in vaccination intention in the experimental group compared to control. This suggests that multiple exposure is critical for the effectiveness of expert-endorsed debunking messages. In addition, these effects are significant regardless of participants' trust toward science. Our results suggest that scientist and medical experts are not simply a generally trustworthy category but also a well suited messenger in contrasting disinformation during vaccination campaigns.

1. Introduction

The effort to vaccinate the world population against SARS-CoV-2 faces several challenges, among which people's hesitancy to get vaccinated. Vaccine hesitancy is a complex phenomenon that affects a significant section of the world population; it affects both beliefs – e.g. on the safety of vaccinations for small children – and behaviour, including the tendency to delay vaccinations. In this study, we present an intervention to test the role of expert endorsement in promoting vaccine uptake as well as positive attitudes and beliefs towards SARS-CoV-2 vaccines.

Determinants of vaccine hesitancy are varied and context-specific, including local culture, historical circumstance, previous vaccination behaviour and even religion and politics [1,2]. Opposition to vaccines and beliefs in conspiracy theories [3,4], free-riding [5], misperception of risk [6,7], and safety concerns, can all affect people's intent to receive a vaccine. For instance, in some studies vaccination hesitancy correlates with the level of education [8,9], but in a study focusing on five low and middle-income countries education had no impact [10]. Designing interventions to increase vaccine uptake is therefore a complex effort whose efficacy depends on local and contextual factors.

SARS-CoV-2 vaccines add a layer of complexity to this picture because the vaccines available today on the market were developed in record times, and the COVID-19 pandemic has become a highly politicised issue due to lock-downs, personal limitations, and other public-policy interventions that were put in place with the intention of managing the pandemic [11]. Additionally, the COVID-19 pandemic was followed by what the WHO has called an infodemic: an excessive amount of information on COVID-19 including false or misleading information in both traditional media and digital media (WHO online). The presence of disagreement among both legitimate and pseudo-experts is likely to increase vaccination hesitancy. Giambi and colleagues [12] report "having received discordant opinions on vaccinations" as one of the main factors associated with hesitancy. It is clear that, for the COVID-19 pandemic where these disagreements occur, the source of the

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information and the concordance between the various sources is decisive in the success of the vaccination campaign.

Several studies have investigated vaccine hesitancy for prospective SARS-CoV-2 vaccines before they were available to the public. Robertson et al. [13] identify key demographic characteristics linked to vaccine hesitancy in the UK population, suggesting that effective vaccination policies need to be targeted. Beyond personal characteristics, research has found that among the strongest predictors of vaccine hesitancy are trust in politics [14] and trust in medical and scientific experts [7]. In Italy, propensity to get vaccinated consistently increased during the acute phase of the epidemic in connection with an increased perception of risk [15]. Propensity likewise was correlated with reduced economic hardships and increased parental education [9].

Despite extensive research on vaccine hesitancy, there is limited causal evidence that traditional information campaigns and behavioural interventions increase vaccination uptake effectively [16–18], with some strategies actually backfiring [19–21]. For that reason, studies investigating the effectiveness of interventions aimed at boosting vaccine uptake are badly needed. Milkman et al. [22] study 19 text-based nudges aimed at boosting flu vaccine uptake after defaulting them into a vaccination appointment during routine primary case visits, showing that reminders sent before the care visit can boost vaccination intake by an average of 5%. Dai et al.[23] have shown how the use of repeated targeted messages, paired with ownership language (as originally proposed by Milkmann), can successfully increase COVID-19 vaccination uptake among different demographic groups.

One area that remains experimentally unexplored is the potential contribution of trustworthy sources in persuading hesitant people to vaccinate against COVID-19. In particular, recent surveys [24] show that experts like scientists and doctors are among the most trusted sources of information in society, so we would expect expert opinion to hold considerable sway in affecting someone's vaccination beliefs and behaviour. Expertise can become a crucial variable in the success of a behavioural intervention for vaccine intake. There is, indeed, a general agreement that placing trust in experts increases pro-vaccine attitudes [25] and trusting the healthcare system contributes to vaccine acceptance [26–28].

Experts can also be pivotal in combating misinformation. For example, a recent study by Zhang and colleagues [29] has shown that when an expert source (research universities) is associated with the fact-checking label of misinformation in vaccines, this tends to minimise the effect of misinformation by acting on the perceived expertise of the source. Scientific agreement significantly affects opinion on debated issues such as the safety of vaccines [30], the anthropogenic origins of climate change [31], safety of GMOs [32], and of Nuclear Energy [33]. According to the Gateway Belief Model theory [34] expert consensus indirectly increases public support by showing how an apparently controversial position is in fact considered to be established by professionals, thus changing public perception on the subject. A recent study has successfully tried to increase policy support by communicating consensus on the emergency nature of the COVID pandemic [7], showing how communication of expert agreement can sway opinions on a developing event for which knowledge is still evolving. The role of expertise is particularly important in the context of the COVID-19 pandemic. In most countries, vaccination is not mandatory but voluntary, and is therefore based solely on the recommendations by experts who make up advisory groups [35]. In this article, we develop an experimental intervention based on the active involvement of medical experts to increase people's trust towards credible information, and, consequently, boost their intention to get vaccinated. We compare the effectiveness of pro-vaccination informative messages that have been endorsed by the members of the expert community vs. messages endorsed by a generic audience of non-experts. The present longitudinal study took place in Italy and ran between March and June 2021, when the third epidemic wave was surging in the country and the vaccination campaign was starting. We exploited the unprecedented opportunity that the COVID-19 immunisation campaign offered, to test behavioural interventions aimed at boosting vaccination uptake and increasing trust towards authoritative sources.

According to Chaiken & Maheswaran [36] trust plays a more important role than expertise, and this asymmetry is indeed confirmed empirically [37]. Speculating, we can imagine that our manipulation had a significant effect because doctors and researchers are a particularly trusted professional category in Italy on top of their perceived competency.

ISPSOS MORI's2021 Global Trustworthiness Index [38] reveals that physicians and researchers are the most trusted categories (both globally and only looking at Italian data) and these two groups of professionals outperform the category of ordinary man/-woman that can resemble our generic endorsement of the control group. If an individual views the expert group (e.g., the majority of physicians and public health experts) as an expert and trustworthy source, then its credibility will be enhanced, and the message this source conveys will have more persuasive power, leading to greater vaccination intention than the message not endorsed by the credible source, as is the case in our findings.

2. Methods

Participants were first recruited from the online platform Prolific through a screening survey ($N = 2904$) at the beginning of the vaccination campaign (December 23rd, 2020 to January 11th, 2021). Only respondents residing in Italy were eligible for participation. In this survey we collected participants' demographics (gender, age, employment/student status, level of education, personal and household income, household size, social media use, history of respiratory diseases and smoking), their initial willingness to receive a vaccine (vaccination intention) and, for vaccine hesitants, their main concern keeping them from getting vaccinated. The size of the sample was determined based on the number of available participants on the recruiting platform. Participants were then randomised into an experimental and a control condition, while keeping the proportion of vaccine hesitancy balanced between the two groups. The Research Ethics Committee of the University of Trento approved the study (protocol No. 2021–001) and subjects provided written informed consent prior to their inclusion. All participants were paid for their time.

The experiment was organised in 7 consecutive waves spanning 10 days each. Data collection started on the 6th of April and ended on June 14th, 2021. Participants had 10 days to respond to the survey, after which data collection for that wave was closed and a new wave started on the eleventh day at around 16.00 CEST. We excluded participants that moved their residence outside Italy during data collection. We decided to keep participants with missing demographic variables contrary to our original pre-registration, as these variables were not used in the pre-registered analyses. We also excluded single responses under specific circumstances. Some participants responded more than once in the same wave, hence we decided to keep their first response only, as the subsequent ones might have been influenced by previous responses. Furthermore, we excluded participant responses from specific analyses in case their responses were not logically plausible. For instance, we excluded data from participants reverting their vaccination status between waves (from "vaccinated" to "not vaccinated") for analyses concerning vaccination behaviour.

Final sample size was $N = 1124$ for the control group, and $N = 1153$ for the treatment group (total $N = 2277$). Supplementary

Table A.3 shows the proportion of participants in each condition divided by how many waves were completed; Table 1 presents the number of participants in each condition by wave, and the retention rate compared to the total sample size.

2.1. Experimental Design

Participants responded to up to seven waves (timeline presented in Fig. 1). All waves measured our variables of interest (vaccine behaviour, intention and beliefs), and all waves except the last one included a message intervention.

In each wave, participants were first asked about their vaccination status (not offered; offered but not vaccinated; vaccinated), their intention to vaccinate (if not vaccinated: "If a vaccine for COVID-19 was offered to me now, I would get it."; 4-point response format from "strongly disagree" to "strongly agree"), and their beliefs about vaccines' protective capabilities for themselves and others (two questions: "My vaccination against COVID-19 protects [myself/others]"; 7-point response format from "completely disagree" to "completely agree"). Questions about vaccination status and intention were adapted from previous Ipsos surveys [40] to keep results comparable.

After responding to the initial questions, participants observed the message interventions (example in Fig. 2). One message was create for each wave, and all messages were built around participants' initial concerns about vaccines, which we collected in the preliminary survey. For example, one of the most common concerns was the fact that vaccines had been developed too quickly; the correlated informative intervention stressed the fact that SARS-CoV-2 Vaccines fast development was possible by cutting most bureaucratic times.

For each wave, participants received one message intervention that included three parts: Participants were first asked their opinion about the concern targeted in that wave (e.g., "I think one should be vaccinated even if there may be side effects."; options: Yes/No/Don't know). After expressing their opinion, participants observed a message in response to the concern. This response was based on the evaluation of doctors and COVID-19 researchers who were shown participants' concerns (see Supplementary Material Expert Survey). The response was framed differently based on the experimental condition: the message in the experimental group explicitly mentioned "doctors and researchers" as the source of information, whereas the message in the control group omitted any reference to experts ("In the December survey in which you participated, we collected some concerns about vaccination against COVID-19. We recently conducted a second survey [E: among doctors and researchers]: The majority of [E: experts/ C: respondents] agrees that [message]"). The third and last part of the intervention was a text providing support for the endorsement message. These texts were based on material from leading health institutions (U.S. Centers for Disease Control and Prevention, European Medicines Agency, U.K. National Health Service). Note that message interventions appeared *after* we collected participants' vaccination status, intention and beliefs. This ensured that participants' answers were not distorted by any potential demand effect. We expected instead that our messages affected responses in the subsequent wave. The complete list of interventions is available at osf.io/m8cr6. The last wave did not include a message, but a series of control questions. Participants answered further questions regarding the COVID-19 pandemic and vaccination campaign. Questions included whether participants completed the vaccination cycle and if they contracted COVID-19 in the previous three months (Yes/No questions), whether they booked or tried to book a slot for getting vaccinated (Yes/No question), whether they would recommend a vaccine to friends and relatives (5-point response format from "completely disagree" to "completely agree"), and a scale measuring coronavirus risk perception [41]. Participants were also asked their main source of information about COVID-19 (multiple choice question) and their trust in the Italian government, scientists, and pharmaceutical companies ("not at all"/"not much"/"some"/"a lot"/"don't know"; questions adapted from the 2018 Wellcome Global Monitor [42]). Lastly, participants completed a survey with a series of scales, including the short-form version of the cultural worldview scale [43], and the Conspiracy Ideation Trait scale [44].

Table 1
Number of participants and retention rate for each wave of the study.

Wave	Group	
	Control	Experimental
1: *April 6–15*	1124 (100%)	1153 (100%)
2: *April 16–25*	1041 (92.6%)	1075 (93.2%)
3: *April 26–May 5*	964 (85.8%)	1003 (87.0%)
4: *May 6–15*	902 (80.3%)	940 (81.5%)
5: *May 16–25*	854 (76.0%)	895 (77.6%)
6: *May 26–June 4*	814 (72.4%)	845 (73.3%)
7: *June 5–14*	761 (67.7%)	802 (69.6%)

2.2. Analyses

Analyses were conducted in R [45] using the multgee [46] package. To test for changes in vaccination uptake we used a Chi squared test comparing the proportion of vaccinated participants between the two experimental conditions. To capture changes in vaccination intention, we included only participants who were not yet offered a dose of vaccine at the end of data collection ($N = 757$). We adopted a repeated measure, ordinal logistic regression for the analysis, including survey wave, experimental group, and their interaction as predictor variables, and participant id as random factor. We interpret the interaction between wave and group as our measure of difference in difference, whereas we consider the non-interaction variables as control measures. Although our analyses focused on participants who completed all waves of the experiment, we include also robustness tests including participants who dropped out before the conclusion of the study and therefore observed fewer messages. Changes in beliefs about vaccines were tested on all participants who completed the study ($N = 1563$). We adopted the same statistical test as for vaccination intentions, repeated for both our belief questions (protection for self, protection for others). Finally, for our measure of vaccination uptake, we included only those participants who were offered a dose of vaccine ($N = 578$). We adopted the 5% significance level to test against the null hypotheses. Post-hoc tests and multiple analyses were corrected for multiple comparisons using a Benjamini-Hochberg procedure. Square brackets indicate 95% confidence intervals.

3. Results

3.1. Vaccination uptake

As part of our pre-registered analyses, we selected all those participants who reported that they were offered a dose of vaccine between the beginning and the end of the experiment. We tested whether having being assigned to the expert endorsement condition increased self-reported vaccination uptake compared to control. With the percentage of vaccinated in the last wave being 63.4% in the expert endorsement condition and 62.6% in the control group, we did not find a significant difference in the percentage of individuals reporting having been vaccinated ($\chi^2(1) = 0.011, p = 0.916, BF_{10} = 0.102$).

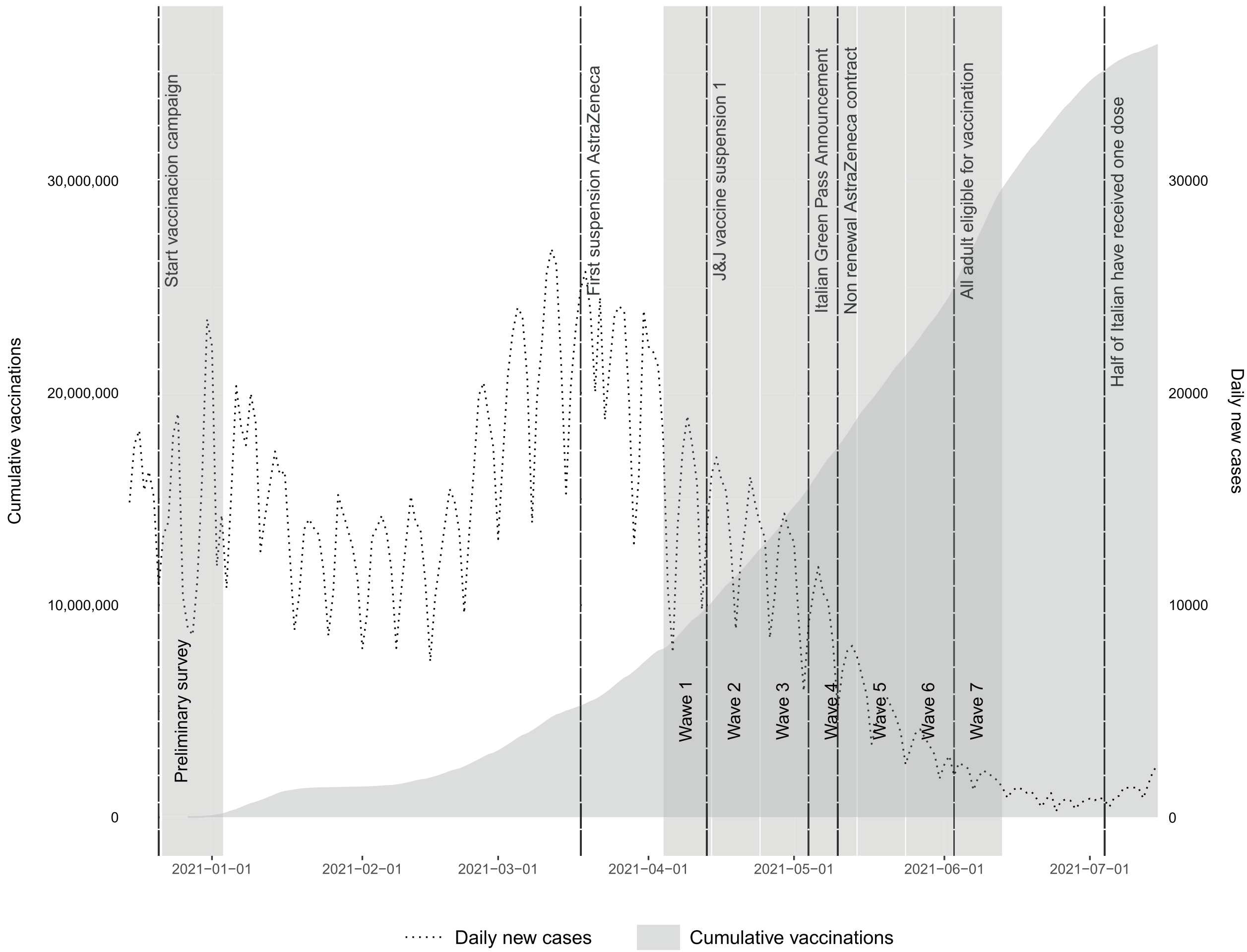

Fig. 1. Timeline of the experiment presenting the different waves as well as some key events of the vaccination campaign in Italy contrasted on the time trend of new daily cases of COVID-19 and the cumulative number of doses administered in Italy [39].

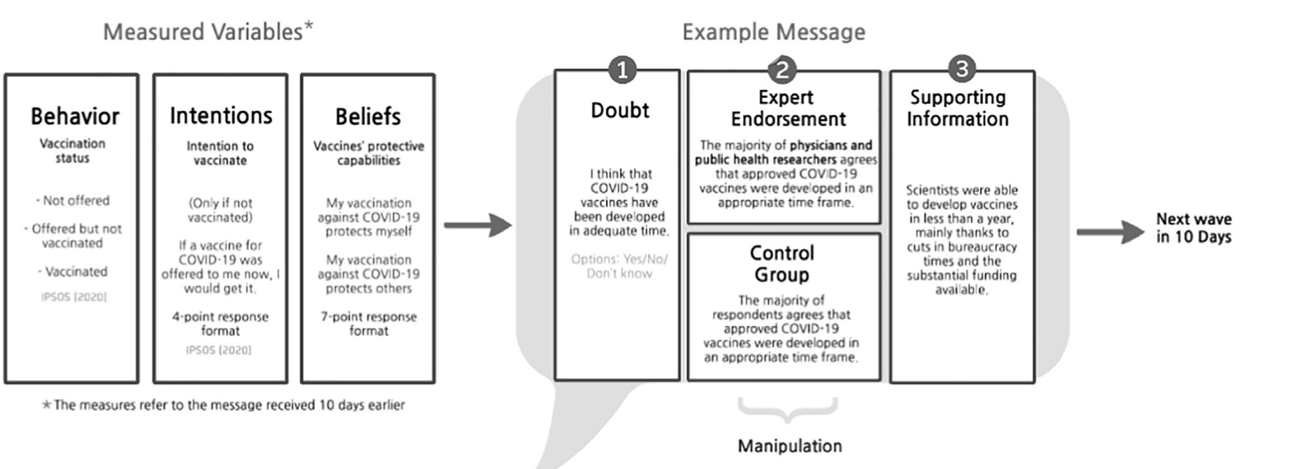

Fig. 2. Flow-chart of one examplary wave. The wave starts with the recording of vaccination behavior, intentions, and beliefs (used as outcomes of the previous message intervention). The recording of the measures of interest are followed by the debunking message endorsed by experts for the treatment group, and by a generic audience for the control.

At the time of the endline, vaccination in Italy had just been made available to young adults (June 3rd). This meant that, contrary to our expectations, a large proportion of the participants in our sample stated that they had not yet the opportunity to get a vaccine dose. For this reason, in the endline we measured whether people who had not yet been vaccinated had booked or tried to book an appointment to do so. We then used self-reported booking in an exploratory analysis as a behavioural proxy for vaccination.

Participants who booked an appointment in the expert endorsement condition at the time of the endline were 60.1%, while only 55.3% in the control group. Thus, 4.8% more participants booked an appointment in the expert endorsement condition. This result, although not significant ($\chi^2(1) = 1.579, p = 0.209, BF_{10} = 0.218$), suggests a trend in line with our hypothesis (i.e. a greater increase in the final number of people vaccinated in the expert's group than in the control group).

3.2. Intention to vaccinate

Analyses indicate that participants' propensity to vaccinate is positively affected by expert endorsement, as measured as a difference in difference between experimental and control group across waves (interaction term wave × treatment: $\beta = .046[.008, .084], z = 2.358, p = .018$). Controlling for their respective baselines, intention to vaccinate (probability of responding "somewhat" or "definitely agree") is + 1.6% higher in the experimental group compared to control at the end of the experiment. Our control variables suggest that intention to vaccinate did not significantly increase in the control group after receiving our non-endorsed messages ($\beta = .013[-.016, .042], z = 0.894, p = .371$), and that there were no significant differences in intention to vaccinate between the two groups before the experiment ($\beta = -.274[-.567, .020], z = -1.829, p = .067$).

Results reported above include only participants who completed the experiment. We additionally explored how many messages are sufficient to observe a significant effect of expert endorsement on intention[1]. Table 2 reports results including different subsets of the sample: the first row includes only participants who read all 6 messages (results above), whereas the last one includes participants who read at least 1 message or more. Expert endorsement significantly affects vaccination intention for participants who read at least four messages, whereas results are less consistent when also including participants who read three or less messages (*Expert endorsement* panel). Intention to vaccinate did not increase significantly in the control group regardless of the number of messages observed (*Control group* panel); Similarly, there were no baseline differences between the two groups, except for the subset of participants who read 2 or more messages, or 5 or more messages (*Baseline differences* panel). For these two subsets the estimated coefficient shows a higher propensity to vaccinate in the control group than in the experimental group. This does not invalidate the reliability of expert endorsement on vaccination intentions described above, and if anything indicates that the effect of our intervention was able to reverse an initial situation in which the experimental group was less inclined to vaccinate.

To further test the robustness of the expert endorsement effect, we repeated the analyses by including a control variable measuring participants' trust towards scientists as measured at the end of the experiment. Even after controlling for this measure expert endorsement was still significant ($\beta = .053[.009, .096], z = 2.362, p = .018$). We repeated the same procedure including a dummy variable capturing participants' level of education, and again the result was significant ($\beta = .046[.004, .060], z = 2.339, p = .019$).

3.3. Beliefs about vaccines

Regression analyses for vaccine beliefs revealed a significant effect of expert endorsement: after the experiment, participants in the experimental group reported greater beliefs about the protectiveness of vaccines compared to the control group. This was true for both questions, protection to self ($\beta = .024[.001, .048], z = 2.020, p = .043$) and protection for others ($\beta = .026[.003, .049], z = 2.190, p = .029$). According to the model, the proportion of "strongly agree" responses for the "*self*" question was + 3.6% higher in the experimental group than in control when comparing to their respective baselines. Similarly, the proportion of "strongly agree" responses for the "*other*" question in the experimental group was + 3.8% higher than control.

Our control variables suggest that beliefs about the protection for others did increase in the control group ($\beta = .026[.009, .043], z = 2.952, p = .003$), but this increase was not significant for beliefs about the protection for self ($\beta = .010[-.008, .027], z = 1.102, p = .270$). Our tests also indicate that beliefs were not balanced before the experiment: participants in the experimental group were less convinced of the protective capabilities of vaccines than control participants (self: $\beta = -.232[-.043, -.420], z = -2.410, p = .016$; others: $\beta = -.247[-.061, -.433], z = -2.602, p = .009$). Greater beliefs in the control group before the experiment might raise the suspicion of potential ceiling effects in this condition. However, average ratings on the 7-point likert item before the experiment were 5.82 for self and 5.59 for others. In addition, the proportion of participants who responded 5 or less on the scale was 29% for the self question and 33% for the others question. Based on these data, we deem a ceiling effect unlikely.

As a final robustness check, we test whether the role of the expert is also significant when including dropped-out participants. These tests show how there is a difference between the two groups even after being exposed to a single message (Supplementary Tables Protectiveness beliefs as a function of number of messages read).

4. Discussion

This study aimed at testing the effectiveness of an intervention meant to promote positive beliefs about vaccines and to increase vaccination intention and uptake in a sample of Italian residents. The intervention consisted of providing participants with pieces of information about the COVID-19 vaccine that addressed their specific reason for being hesitant in vaccinating (debunking information). Concerns were expressed by the participants themselves at the baseline, and response messages were vetted by a team of medical experts and researchers. Informative text snippets were provided to the same individuals in 7 different waves 10 days apart one from the other. While the same information was provided to all participants, message endorsement was systematically manipulated. Participants in the experimental group were told that the information was supported by the majority of physicians and public health researchers respondents (expert endorsement), while participants in the control group were told that the information was supported by the majority of respondents (anonymous endorsement). The purpose of the study was to observe whether information endorsed by a medical source was more effective in getting people to vaccinate than information endorsed by an anonymous source. To do so, participants were followed throughout the 7 waves of the longitudinal experiment and their behaviour, intentions and beliefs monitored. Results show that an expert endorsement ("most experts agrees that…"), compared to a generic endorsement ("most respondents [to a survey] agrees that…"), while not immediately increasing vaccination uptake, had a significant positive impact both on vaccination intentions and beliefs about the protectiveness of COVID-19 vaccines. Our first pre-registered analysis (vaccination behaviour change)

[1] Interpretation of these analyses is valid if there are no confounding factors affecting how many waves participants completed before dropping out. In other words, whether or not taking part in some waves of the study should not be dictated by endogenous factors. A potential confound is that only participants who were strongly motivated completed multiple consecutive waves. For this reason, we allowed participants to re-enter the experiment even after missing waves. We repeated the analysis by including these data points and found comparable results to the ones reported in the main text (Supplementary Table Vaccination intention including non-consecutive participation).

Table 2
Vaccination intention as a function the number of messages read (including non-consecutive participation.)

	N	Expert endorsement			Control group			Baseline differences		
Messages		β	z	p	β	z	p	β	z	p
6	757	0.046 [0.008,0.084]	2.358	0.018*	0.013 [-0.016,0.042]	0.894	0.371	−0.274 [-0.567, 0.020]	−1.829	0.067
5+	826	0.044 [0.008,0.081]	2.392	0.017*	0.011 [-0.017,0.038]	0.768	0.443	−0.302 [-0.584,-0.020]	−2.098	0.036*
4+	876	0.038 [0.002,0.074]	2.083	0.037*	0.013 [-0.014,0.039]	0.938	0.348	−0.259 [-0.534, 0.016]	−1.845	0.065
3+	928	0.034 [-0.002,0.070]	1.841	0.066	0.015 [-0.012,0.041]	1.093	0.274	−0.232 [-0.501, 0.036]	−1.695	0.090
2+	1007	0.036 [0.001,0.072]	2.018	0.044*	0.013 [-0.014,0.039]	0.948	0.343	−0.272 [-0.531,-0.014]	−2.065	0.039*
1+	1109	0.030 [-0.005,0.065]	1.693	0.090	0.016 [-0.009,0.042]	1.246	0.213	−0.209 [-0.454, 0.035]	−1.676	0.094

yielded a null result, thus not supporting an impact of expert endorsement in increasing vaccination rates. We note however that data collection occurred while most participants did not have access to vaccines, as many of the early vaccination slots for citizens under 40 years of age were available only weeks after the experiment. Possible evidence in support of this explanation is the greater (though not significant) rate in attempts to book the vaccination in the experimental group compared to control. Unfortunately, no follow-up data collection could be conducted to verify this hypothesis: a major obstacle was the introduction of semi-coercive policies such as the EU digital COVID certificate, which strongly influenced the incentives and politicisation of vaccination. Conversely, data on vaccination intention revealed a significant positive influence of expert endorsement. In addition, an exploratory analysis on the cumulative effect of debunking messages suggests that expert endorsement requires repeated exposure in order to significantly orient participants' intentions. One objection originating from this observation is that the intervention could have worked only for 'super-participants' who were willing to participate in the experiment longer than an average participant sorted from the general population. We deem this possibility unlikely on the grounds that control analyses replicate the findings once we allow for participants to re-enter the experiment even after having dropped out. Although we remain sceptical about survival effect concerns, we acknowledge that the duration of the intervention could be shortened in order to reduce the risk of drop outs and improve its benefits in a rapidly developing vaccination campaign. Lastly, our experiment measured participants' beliefs about the ability of vaccines to protect vaccinated persons and those close to them. In this respect, endorsement by experts acted as a small but significant lever: at the end of the experiment, participants in the experimental group were more convinced of the protectiveness of vaccines compared to the control group. Notably, this effect remained significant even when including in the analysis participants who only observed one debunking message.

Our findings can be explained as a combination of different effects converging on the same outcome. The effect of the source type (expert endorsement vs. public endorsement) on vaccination intention that we found in our study is in line with converging evidence indicating that the source of information plays a key role in health communication [47]. This evidence shows that the source of information does not merely constitute an incidental feature of the information, rather it becomes part of the mental representation that people form of the information itself and is then used in subsequent evaluations [48,49]. For example, source credibility was found to affect participants' judgements of the likelihood that a character would perform a certain behaviour [50]. The source of information was also found to be relevant for reducing people's reliance on misinformation. For example, when a highly trusted source of information corrected a wrong assertion or retracted a piece of misinformation, people reduced reliance on that incorrect piece of information more than when it was corrected or retracted by a low trusted source [51,52]. Likewise, correction from a reputable source such as the Center for Disease Control reduced misperceptions about the causes of Zika virus spread more than when another user was used as source [53]. The mechanism that conveys the source effect is assumed to be related to the degree of belief in the information. According to this explanation, the source of an information makes the information more or less believable, that is, people believe information that comes from trusted sources more than information that comes from sources they do not trust. Indeed, the extent to which people believe in an evidence was found to be important to correct social impressions [54]. It must be noted however that the believability hypothesis obtained only mixed evidence so far [51].

Vaccination habits are also closely related with health-care provider recommendations. Physician suggestions are proved to be beneficial because they serve as a prompt to action, but various other factors may also play a role [16]. It is important to notice that in the literature, interventions based on information or endorsement are often proved ineffective while strategies like reminders, primes, defaults, and implementation intentions are successful to help closing the intention behaviour gap. In particular, interventions to induce vaccination are notably effective when they intervene directly on behaviour while remain largely ineffective when attempting to modify individuals' attitudes and beliefs about vaccination [16].

From a theoretical perspective, our results are consistent with both an explanation that implicates the theory of planned action [55] and an explanation based on theories of persuasion [36]. Using the language of the theory of planned behavior [55], the results of our study could be explained by an increase in the subjective norm. To the extent that an individual considers the expert group (e.g. the majority of physicians and public health experts) among other individuals who are significant to him or her (subjective norms), then, according to the theory, behavioural intentions to vaccinate should increase when this information is made explicit compared to when this information is muted, as shown by our results. Similarly, our intervention has probably increased the persuasiveness of the message. According to the credibility heuristic [36], if an individual views the expert group (e.g. the majority of physicians and public health experts) as an expert and trustworthy source, then its credibility will be enhanced, and the message this source conveys will have more persuasive power, leading to greater vaccination intention than the message not endorsed by the credible source.

In the case of our study, Italian physicians and medical researchers are seen as both expert and trustworthy. Although with our data we cannot disentangle which of the two aspects is determinant, a similar experimental study suggests that source trustworthiness is more relevant than source expertise [37].

We have no evidence from the data of our study of the mechanism by which the source of the information acts on intentions to vaccinate, but we can assume that it makes the information supported by medical experts more trustworthy and therefore more convincing than that coming from non-experts. Future studies will have to ascertain whether or not this is the mediating mechanism of the source effect. Moreover, our findings that providing debunking information endorsed by medical experts is effective in increasing vaccination intention is in line with the literature on debunking interventions. As previously stated, debunking interventions make clear reference to the fears and doubts of the respondents by providing specific information that counteracts them [56]. Thus, the debunking intervention might have strengthened the source effect: the source of information effect might have been effective only because it was in the context of a debunking intervention. However, we did not manipulate this factor directly, so we can not say if a non-debunking intervention might produce the same source effect that we found in our debunking intervention. Nevertheless, we are quite confident that the source effect was significant because it was embedded in a debunking intervention. Our results are in line with others showing a positive effect of debunking on correcting misinformation [57,58] especially when health agencies were used as a source of information compared to social peers [59]. Put together, these results are all the more remarkable considering that expert endorsement was tested against a rigorous and stringent benchmark. Message interventions exploited many strategies of the behavioural toolkit: a use of debunking information, the tailoring of messages to concerns expressed by participants themselves, the framing of the message in terms of a descriptive social norm to express agreement on a contended issue. At the same time, we expected the results of our intervention to be still visible after a ten-day period in order to avoid that responses could be biased by the intentions of experimenters. Despite such an experimental setting, our results are bringing evidence in favour of the role of experts in supporting science-based policies.

5. Limitations

Our study comes with several limitations, particularly concerning the experimental setup. A first concern is the quasi-experimental nature of the study, which relied on the unfolding of the vaccination campaign in order to measure changes in our variables of interest. Vaccination uptake was the most affected, given the several delays that prevented an earlier access of many citizens to vaccine doses. Furthermore, the development of the vaccination campaign might have fostered new concerns with respect to vaccines that could not have possibly been captured in the early stages of the study, when we collected the initial doubts of participants. This could have consequently weakened the effect of some of our debunking messages. In addition to delays and scandals of the vaccination campaign, variations in the fear of infection over the months of the data collection may also have interacted and toned down the results of our manipulation. Another critical aspect is the self-reported measures of vaccine offer. If misreported and subject to an interaction with our manipulation, this might have affected the number of vaccinated and non-vaccinated in our study. All these external factors are only problematic to the extent that they interact with our manipulation but we cannot completely rule out this possibility.

Perhaps one of the strengths of the experiment's design, repeated messaging, may also pose a problem in terms of both economic viability and participant drop-outs. One future development of messaging campaigns could rely on efficient targeting of participants' concerns, so as to reduce the length of the intervention and increase the sense of personalisation of debunking messages. Reducing the time between collection of concerns and the sending of messages might also increase the salience and relevance of the intervention that could otherwise risk of feel outdated.

It must be added that although behavioural intentions generally correlate with manifest behaviour in laboratory settings [60,61] and in correlational studies [62], there are, however, circumstances in which this relationship does not hold [63]. For example, if the measure of intention is too broad and not specific to the given behaviour and the given situation, the relationship gets weaker [64]. Moreover, intentions may change after they have been measured if the person does not immediately enact the behaviour in question. It has also been hypothesized that the intention-behaviour relationship is strengthened when one perceives or actually has more control over behaviours and is weakened otherwise [65].

Another critical point of our study is the potential country-specificity of our results. Looking at the literature on the differences between countries it emerges that Italy is comparable with US and other major countries in terms of risk perception towards covid [66]. What differentiates Italy from other countries surveyed in Dryhurst et al.[66] is the role of prosociality as explanatory factor, that explains the most variance in the models for Italy while it is not a crucial predictor for most other countries. This suggest that we should be especially cautious in speculating on the mechanism and its external validity.

Lastly, our experiment relied on an online sample that, despite its considerable size, was not representative of the Italian population as it was on average younger and better educated. For this reason, the present results need to be interpreted with caution and require further testing to consider the effectiveness of expert endorsement for all segments of the population. In summary, our intervention suggests that trusted experts, when in agreement, might have a persuasive impact on listeners, and could contribute to the success of health or other science-based policies.

6. Conclusions

Physicians play a crucial role in increasing people's adherence to vaccination campaigns. In this longitudinal study that followed a group of Italians for months, recording their fears and choices about vaccines, we show how this can be done. By offering information endorsed by expert addressing the main doubts raised by hesitant people (debunking), it was possible to increase participants' intention to vaccinate. Source's key role in health communication is abundantly discussed in the source credibility literature (e.g. [67,47]), but in most previous studies information source was manipulated by associating it directly to the information itself (i.e. physicians say that COVID-19 vaccines are safe) (e.g. [68,69]). In our results instead, we found that the medical source is effective when used to endorse a belief (i.e. The majority of physician respondents agree that COVID-19 vaccines are safe). Our data indicate a growing responsibility and relevance of communication by institutions and physicians. Institutional communication should increase and focus efforts to address relevant concerns of hesitant citizens about possible side effects of vaccination. In this regard, physicians should be more present in institutional communications and they should directly argue and respond to people's main fears.

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.

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