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Who is likely to vacillate in their COVID-19 vaccination decision? Free-riding intention and post-positive reluctance

This is the final peer-reviewed author's accepted manuscript (postprint) of the following publication:

Published Version:

Caserotti M., Gavaruzzi T., Girardi P., Tasso A., Buizza C., Candini V., et al. (2022). Who is likely to vacillate in their COVID-19 vaccination decision? Free-riding intention and post-positive reluctance. *PREVENTIVE MEDICINE*, 154, 1-9 [10.1016/j.ypmed.2021.106885].

Availability:

This version is available at: <https://hdl.handle.net/11585/901011> since: 2022-11-09

Published:

DOI: <http://doi.org/10.1016/j.ypmed.2021.106885>

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Title Page

Who is likely to vacillate in their COVID-19 vaccination decision?

Free-riding intention and post-positive reluctance

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Abstract

Despite the actual availability of COVID-19 vaccines to combat the pandemic, many people are still vacillating in their decision to vaccinate. In this study, we considered the effect of two relevant contextual issues on vaccination intention: the number of people infected with COVID-19 is increasing, and the pace of vaccination is gaining speed. Specifically, we hypothesized that having already contracted SARS-CoV-2 (*post-positive reluctance*) could lead people to underestimate the importance of vaccination. Moreover, as the number of vaccinated people increases, more hesitant people could fall into the *free-riding intention* category, benefitting from the immunity provided by others' vaccinations. Vaccine hesitancy becomes more critical as the vaccination campaign proceeds: at one point, it will be inevitable to deal with hesitant people. This study is part of a WHO Regional Office for Europe project and involved a representative sample of 5,006 Italians interviewed in January–February 2021. In case of post-positive reluctance, both young age and female gender increase vaccine hesitancy, while a high level of education reduces free-riding intention. Considering post-positive reluctance and free riding, a protective effect on hesitancy is associated with negative affective states, adherence to protective behaviors, trust in health information sources, and resilience. In contrast, increased vaccine hesitancy is associated with a high level of conspiracy-mindedness and trust in media information sources. Recognizing and studying the post-positive reluctance and the phenomenon of free-riding people can help us to become more efficient in combatting the virus.

Keywords: COVID-19; vaccination intention; vaccination hesitancy; post-positive reluctance; free-riding intention.

Abbreviations: COronaVirus DIsease of 2019 (COVID-19); Severe Acute Respiratory Syndrome CoronaVirus-2 (SARS-CoV-2); Willingness To get Vaccinated (WTV); Explorative Factorial Analysis (EFA).

1. Introduction

After more than a year, the SARS-CoV-2 pandemic remains ongoing, but the situation is evolving, mainly due to the growth of scientific knowledge and the development of vaccines. To date, studies have mostly focused on vaccine hesitancy *per se* (Lazarus et al., 2021; Caserotti et al., 2021), missing new salient aspects that need to be considered: many infected people have acquired some natural immunity, and vaccination proceeds at a rapid pace. If reaching out and vaccinating people who accept vaccination is certainly crucial (and easy), the real challenge is to convince reluctant persons. We know, for example, that people's beliefs and attitudes about vaccines are mainly shaped by the number of affected people and, in turn, by changes in individual risk perception (e.g., Caserotti et al., 2021; Schwarzingler et al., 2021). We also know that even politics may play a role in modifying people's beliefs and attitudes; for example, claims made during the US presidential campaign engendered worries that vaccines were rushed and thus not safe (Limaye et al., 2021; Thorp, 2020). Additionally, concerns are driven by the new technologies used for the development and manufacturing of some vaccines, such as worries related to the mRNA vaccines, sometimes fueled by the anti-vax community leveraging conspiracy beliefs (Ullah et al., 2021; Chirumbolo, 2021). Fortunately, over time, vaccine acceptance has increased globally (Daly et al., 2021; Imperial College London, 2021), but COVID-19 vaccine hesitancy could jeopardize high coverage, thus prolonging the need for lockdowns and other restrictive measures, with potentially negative socioeconomic consequences. According to a recent model developed by the Imperial College of London, the "mortality over a 2-year period could be up to 8 times higher in countries with high vaccine hesitancy compared to an ideal vaccination uptake," resulting in an additional 236 deaths per million population (Johns & van Elsland, 2021).

It is noteworthy that the problem of vaccine hesitancy becomes more and more critical as the vaccination campaign proceeds. As time goes by, it is inevitable to deal with hesitant persons, which can mean not only the outright vaccine refusers but also those who for different reasons avoid vaccination. Here, we hypothesize that having already contracted SARS-CoV-2, especially if symptoms are mild, could lead people to underestimate the danger of the virus and also the importance of getting vaccinated despite recommendations by guidelines (CDC, 2021; ECDC, 2021). Additionally, as more people are getting vaccinated and the epidemiological situation improves, restrictions will decrease, and people still having lingering doubts about vaccination will be even less motivated to get vaccinated and may be tempted by free riding, benefitting from the immunity provided by others' vaccinations but

hindering the protection of the whole community (Milman et al., 2021). From this perspective, it is essential to identify the predictors of vaccine acceptance and to establish who is likely to vacillate in their COVID-19. In this study, conducted in the early stages of the vaccine roll-out in Italy, we first estimated the predictors of COVID-19 vaccination intention and then modeled the additional effect of factors predicting a person's reluctance to vaccinate after testing positive for COVID-19 (i.e., *post-positive reluctance*) and factors predicting unwillingness to vaccinate while counting on others getting vaccinated (i.e., *free riding*). Investigating these factors will shed a unique light on vaccine acceptance and reluctance.

2. Methods

2.1 Participants

The online questionnaire was administered in two waves (January–February 2021) by a survey company (BDA-Doxa), which selected a national Italian representative sample (N=5,006), weighted by gender, age (18–70 years), area of residence, size of living centers, education, and employment status (Unemployed and Employed). Employment status was further classified as Unemployed, Employed, and Employed as a health worker. Details about the sampling strategy, response rates, and weights can be found in the supplementary materials (Method S1).

2.2 Materials and procedure

This cross-sectional study is part of a larger project promoted by the WHO Regional Office for Europe called “*Monitoring knowledge, risk perceptions, preventive behavior and trust to inform pandemic outbreak response*” and conducted in more than 30 countries (see WHO 2021 for the full protocol). In Italy, the study has been approved by the Ethical Committee of the Italian coordinating institution (protocol 286/2020, registration ISRCTN 39724).

In the present study, we considered a subset of the data, including participants' *Willingness To get Vaccinated* (“WTV,” hereinafter) against SARS-CoV-2, *post-positive reluctance*, and *free-riding intention*, all rated on a 7-point response scale. In addition to the demographic variables used to collect the representative sample, participants were asked during the survey whether they suffered from chronic diseases (“Yes,” “No,” “Do not know”), whether they had contracted COVID-19 (“Yes,” “No,” “Do not know”), whether they knew people who had contracted the disease (“No,” “Yes and still alive,” “Yes, deceased”), and their employment status (“Unemployed,” “Employed,” “Employed as health worker”). Participants

were asked about their concerns for the direct economic consequences of the pandemic (rated on a 7-point scale). The questionnaire also included the 5-item Conspiracy Mentality Questionnaire (refs) and three items taken from the Brief Resilience Scale (refs). Finally, participants were asked whether they thought it would be appropriate for the entire population to follow national vaccination plans (*vaccination propensity*; “Yes,” “No,” “Do not know”). Questions related to other investigated domains are described in detail in the following section.

2.3 *Statistical Analysis*

2.3.1 *Descriptive analysis*

The study variables were summarized in frequency tables and figures (frequency for categorical variables, median and InterQuartile Range (IQR) for continuous variables). Non-parametric tests were computed to compare the distribution of variables on the ordinal Likert scale across the two waves. Categorical variables were compared using chi-squared or Fisher's exact test where expected frequencies in any combination were less than 10. Statistical significance was assumed at the 5% level.

2.3.2 *Dimensionality reduction - exploratory factor analyses*

Using only the data of the first wave (N=2,504), 11 different Explorative Factorial Analyses (EFAs) were performed on groups of variables related to specific domains: 1) COVID-19 perceived risk, 2) Negative affective states, 3) Control, 4) Protective behaviors, 5) Trust in media information sources (e.g., traditional and social media), 6) Trust in health information sources (e.g., Ministry of Health, WHO), 7) Frequency of use of media information sources, 8) Frequency of use of health information sources, 9) Trust in health institutions, 10) Conspiracy-mindedness, and 11) Resilience.

Since the scales of all variables reported 7-point discrete ordinal values, each factorial analysis was performed on the polychoric correlation matrix, hypothesizing normally distributed continuous latent variables. We extracted from each EFA only the first factor, which explained the highest percentage of variance: the amount of variance explained by the one-factor solution was satisfactory, ranging from 40% to 65%, with the exception of COVID-19 perceived risk and Control, which explained a limited amount of variability (28% and 22%, respectively). The estimated loadings were then used to calculate the regression

factor scores for both waves. Regression scores were categorized in tertiles (1st tertile = low risk; 2nd tertile = medium risk; 3rd tertile = high risk) for inclusion in the following regression models. For each EFA, the number and the name of items included, their internal consistency (Cronbach's α), the estimated loadings, and the proportion of deviance explained are reported in Table S1 of the Supplementary Material.

2.3.3 *Cumulative Logistic Models*

Each participant reported his/her WTV on a 7-point Likert scale. To evaluate which factors influenced the respondent's motivation to take this measure against COVID-19, we employed Cumulative Logistic Models (CLM): one model was estimated on WTV, and two models were used to predict vacillation (see Supplementary Material Method S2 for more details).

3. Results

3.1 Descriptive analysis

The main characteristics of the sample are reported in Table 1.

Characteristics	Overall, N = 5,006 ^I	Wave		P-value ²
		1 (Jan. 8-18, 2021) N = 2,504 ^I	2 (Feb. 8-19, 2021) N = 2,502 ^I	
Gender				0.98
Female	2,520 (50%)	1,260 (50%)	1,260 (50%)	
Male	2,486 (50%)	1,244 (50%)	1,242 (50%)	
Age-class				>0.99
18-34	1,302 (26%)	651 (26%)	651 (26%)	
35-44	962 (19%)	482 (19%)	480 (19%)	
45-54	1,185 (24%)	592 (24%)	593 (24%)	
55-70	1,557 (31%)	779 (31%)	778 (31%)	
Educational level				0.043
Low (0-8 ys)	2,052 (41%)	1,027 (41%)	1,025 (41%)	
Medium (9-13 ys)	1,602 (32%)	767 (31%)	835 (33%)	
High (13+ ys)	1,352 (27%)	710 (28%)	642 (26%)	
Geographical area				0.99
North-West	1,340 (27%)	669 (27%)	671 (27%)	
North-East	964 (19%)	484 (19%)	480 (19%)	
Center	966 (19%)	479 (19%)	487 (19%)	
South and Islands	1,736 (35%)	872 (35%)	864 (35%)	
Employment status				0.41
Unemployed	2,371 (47%)	1,196 (48%)	1,175 (47%)	
Employed	2,431 (49%)	1,215 (49%)	1,216 (49%)	
Health care worker	204 (4.1%)	93 (3.7%)	111 (4.4%)	
Vaccination propensity				0.37
Low	3,642 (73%)	1,800 (72%)	1,842 (74%)	
Medium	590 (12%)	307 (12%)	283 (11%)	
High	774 (15%)	397 (16%)	377 (15%)	
WTV	6 (4, 7)	5 (4, 7)	6 (4, 7)	0.13
Post positive reluctance	2 (1, 4)	2 (1, 4)	2 (1, 4)	0.82
Free riding intention	3 (2, 4)	3 (1, 4)	3 (2, 4)	0.061
Economic concern	5 (4, 6)	5 (4, 6)	5 (4, 6)	0.97
Chronic diseases				0.71
No	3,771 (75%)	1,874 (75%)	1,897 (76%)	
Don't know	177 (3.5%)	89 (3.6%)	88 (3.5%)	
Yes	1,058 (21%)	541 (22%)	517 (21%)	
Past COVID-19 disease				0.015
No	4,205 (84%)	2,129 (85%)	2,076 (83%)	
Don't know	466 (9.3%)	233 (9.3%)	233 (9.3%)	
Yes	335 (6.7%)	142 (5.7%)	193 (7.7%)	
Direct COVID-19 contact				0.10

No	1,388 (28%)	709 (28%)	679 (27%)
Yes, but still alive	1,591 (32%)	818 (33%)	773 (31%)
Yes, deceased	2,027 (40%)	977 (39%)	1,050 (42%)

¹ Median (IQR) or Frequency (%)

² Pearson's Chi-squared test; Wilcoxon rank sum test

Table 1. Main characteristics of the sample, overall and by wave.

Due to the sampling strategy, the distribution of gender (50% females), age, employment, and geographical area of residence were the same in both waves (Table 1). Educational level was low in 41% of the sample, with a slight reduction in the number of respondents who placed in the highest category in the second wave ($p=0.043$). The WTV was very high (median 6, Figure 1), while the post-positive reluctance or the free-riding intention was generally low (high intention with values 6 or 7 for only 10.1% and 8.2%, respectively, of the sample), with no statistically significant difference between the two waves (Table 1, Figure 1). In general, concerns about the economic consequences were medium to high (median 5), while a relevant proportion (21%) of respondents reported the presence of a chronic disease. The lifetime prevalence of COVID-19 disease was 6.7%, with an increase in the second wave (from 5.7% in wave 1 to 7.7% in wave 2, $p=0.015$); at least 40% of respondents directly knew someone who had died from COVID-19.

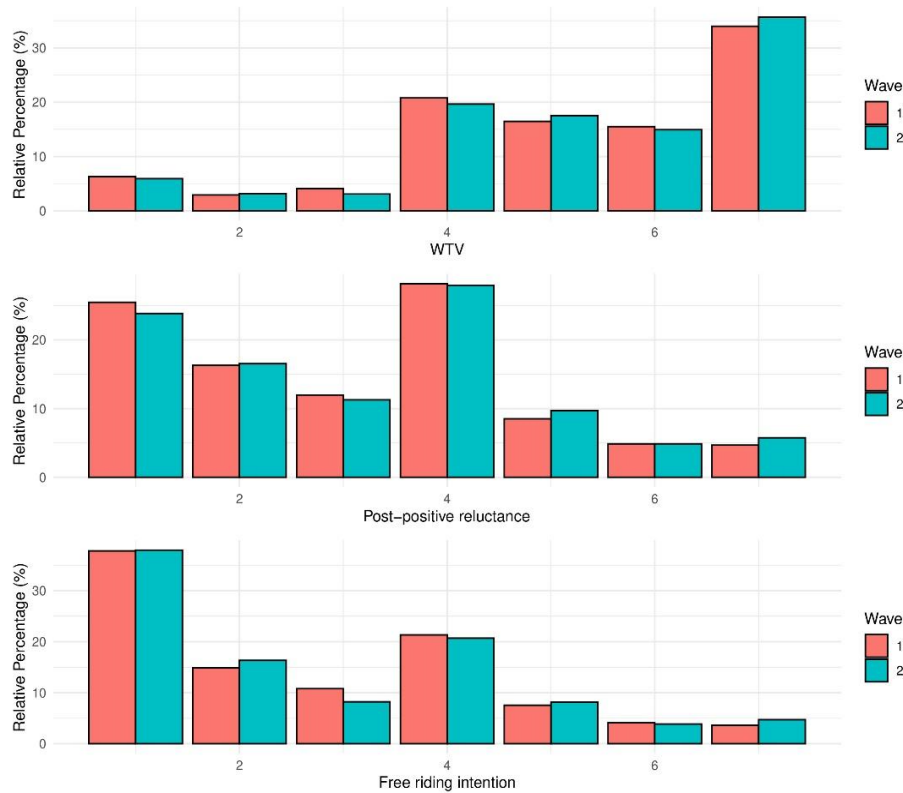


Figure 1. Marginal distribution of the WTV and vaccine hesitancy due to post-positive reluctance and to free riding intention.

The pairwise marginal distribution and Spearman's correlations between 11 scores resulting from the EFAs performed on 11 dimensions are shown in Figure 2. We found good agreement between trust and frequency of use of information obtained from health institutions (Spearman's $\rho=0.56$) and from media ($\rho=0.66$). A strong correlation was seen between trust in health institutions and in the information they provide ($\rho=0.81$). The COVID-19 perceived risk score was positively correlated with the negative affect score ($\rho=0.57$) and negatively correlated with the score related to the feeling of control ($\rho=-0.39$). The scores produced by the 11 indices did not change by sampling wave, with the exception of the frequency of use of health information sources, which increased ($p=0.019$; Table 2).

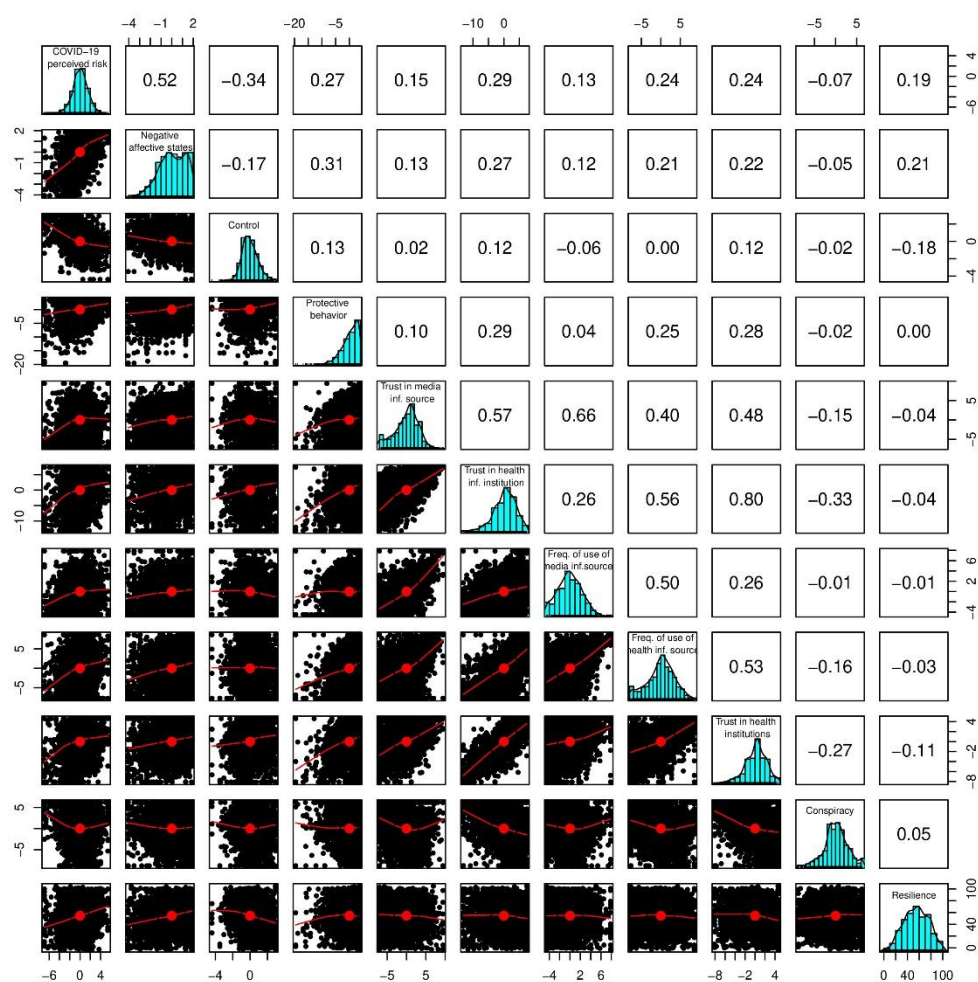


Figure 2. Pairwise marginal distribution and Spearman's correlation between 11 regression scores resulted by the EFAs.

	Overall, N = 5,006 ¹	Wave		p-value ²
		1, N = 2,504 ¹	2, N = 2,502 ¹	
COVID-19 perceived risk	0.05 (-0.89, 1.00)	0.06 (-0.88, 1.02)	0.05 (-0.91, 0.98)	0.77
Negative affective states	0.08 (-0.84, 1.16)	0.04 (-0.84, 1.06)	0.09 (-0.84, 1.16)	0.30
Control	-0.11 (-0.68, 0.60)	-0.11 (-0.68, 0.54)	-0.11 (-0.68, 0.64)	0.75
Protective behavior	0.73 (-1.75, 2.59)	0.74 (-1.75, 2.53)	0.73 (-1.74, 2.59)	0.77
Trust in media information sources	0.4 (-1.9, 2.0)	0.4 (-1.9, 2.0)	0.5 (-1.9, 2.1)	0.60
Trust in health information sources	0.5 (-2.3, 2.9)	0.5 (-2.4, 2.8)	0.5 (-2.3, 2.9)	0.11
Frequency of use of media information sources	-0.05 (-1.70, 1.67)	-0.05 (-1.69, 1.70)	-0.07 (-1.70, 1.64)	0.66
Frequency of use of health information sources	0.4 (-2.2, 2.4)	0.2 (-2.4, 2.3)	0.4 (-2.0, 2.4)	0.019
Trust in health institutions	0.37 (-1.39, 1.68)	0.37 (-1.39, 1.53)	0.37 (-1.39, 1.68)	0.61
Conspiracy	0.1 (-1.4, 1.7)	0.1 (-1.4, 1.7)	0.1 (-1.4, 1.7)	0.76
Resilience	-0.04 (-1.25, 1.19)	-0.04 (-1.10, 1.20)	-0.04 (-1.26, 1.18)	0.14

¹Median (IQR) or Frequency (%); ²Wilcoxon rank sum test

Table 2. Factorial scores of the 11 dimensions overall and by wave.

3.2 Cumulative Logistic Models

In Table 3, the results of the first CLM regression showed no difference in the WTV variable between waves. People over age 54 reported a 42% increase in WTV compared to the reference group (<34 years), while females showed the opposite effects (-18% vs. males, $p < 0.001$). The educational level exerted a progressive and greater effect on the intention to get the COVID-19 vaccine (from medium OR: 1.15 to high OR: 1.52) as did being a health care worker (OR: 1.56, $p = 0.004$). Having a chronic disease increased by 21% the intention to get the COVID-19 vaccine, and a similar effect was attributable to knowing a person who had died from COVID-19 (OR: 1.29; 95% CI: 1.13–1.47). The concerns about the economic consequences also moderately increased the WTV (OR: 1.39; 95% CI: 1.23–1.56). Having already had COVID-19 reduced, but not in a statistically significant way, the WTV. Agreeing with immunization practice strongly increased the likelihood to get a COVID-19 vaccine (medium vs. low OR: 2.60; 95%CI: 2.11–3.20; high vs. low OR: 18.06; 95%CI: 14.78–22.07). Belief in the appropriateness of the government measures against COVID-19 moderately increased the probability of a higher WTV (OR: 1.57; 95%CI: 1.36–1.82). Among the 11-dimensional scores, the following variables were statistically significant and were included in the model: 1) COVID-19 perceived risk, 2) Negative affective states, 3) Protective behaviors, 4) Trust in media information sources, 5) Trust in health information sources, 6) Frequency of use of health information sources, 7) Trust in health institutions, and

8) Conspiracy-mindedness. COVID-19 perceived risk, negative affective states, protective behaviors, trust in health information sources, frequency of use of health information sources, and trust in health institutions were reported to have a positive effect on WTV, with ORs ranging from 1.17 (95%CI: 1.01–1.36) among those with high (vs. low) frequency of use of health information sources to 2.41 (95%CI: 1.97–2.94) among respondents with a high trust in information from health institutions. High trust in the information provided by media information sources (OR: 0.85; 95%CI: 0.73–0.99) and a progressive adherence to conspiracy theories (OR: 0.77 and 0.57 in the medium vs. low and high vs. low category comparison, respectively) had a negative effect on intention to get the COVID-19 vaccine.

Variables	OR	95% CI	P-value
Wave [2 nd]	1.04	0.94 – 1.16	0.428
Age-class [35-44]	0.91	0.77 – 1.07	0.269
Age-class [45-54]	1.05	0.89 – 1.23	0.586
Age-class [55-70]	1.42	1.23 – 1.66	<0.001
Gender [Female]	0.82	0.73 – 0.91	<0.001
Educational level [Medium]	1.15	1.01 – 1.30	0.033
Educational level [High]	1.52	1.31 – 1.75	<0.001
Employment status [Employed]	0.90	0.81 – 1.01	0.064
Employment status [Health care worker]	1.56	1.15 – 2.10	0.004
Chronic disease [Don't know]	1.09	0.82 – 1.46	0.543
Chronic disease [Yes]	1.21	1.06 – 1.39	0.005
Direct COVID-19 contact [Yes, but still alive]	1.14	1.00 – 1.31	0.059
Direct COVID-19 contact [Yes, deceased]	1.29	1.13 – 1.47	<0.001
Previous COVID-19 disease [Don't know]	0.86	0.72 – 1.03	0.107
Previous COVID-19 disease [Yes]	0.88	0.71 – 1.09	0.243
Economic Concern [>5]	1.39	1.23 – 1.56	<0.001
Vaccination propensity [Medium]	2.60	2.11 – 3.20	<0.001
Vaccination propensity [High]	18.06	14.78 – 22.07	<0.001
Supporting public health policies [>5]	1.57	1.36 – 1.82	<0.001
COVID-19 perceived risk [Medium]	1.13	0.99 – 1.29	0.072
COVID-19 perceived risk [High]	1.28	1.11 – 1.49	0.001
Negative affective states [Medium]	1.25	1.09 – 1.42	0.001
Negative affective states [High]	1.46	1.26 – 1.69	<0.001
Protective behavior [Medium]	1.29	1.13 – 1.46	<0.001
Protective behavior [High]	1.51	1.32 – 1.74	<0.001
Trust in media information sources [Medium]	1.03	0.90 – 1.18	0.622
Trust in media information sources [High]	0.85	0.73 – 0.99	0.032
Trust in health information sources [Medium]	1.33	1.13 – 1.56	<0.001
Trust in health information sources [High]	2.41	1.97 – 2.94	<0.001
Frequency of use of media information sources [Medium]	1.24	1.09 – 1.42	0.001
Frequency of use of media information sources [High]	1.17	1.01 – 1.36	0.042
Trust in health institution [Medium]	1.25	1.07 – 1.45	0.004
Trust in health institution [High]	1.50	1.24 – 1.81	<0.001
Conspiracy [Medium]	0.77	0.67 – 0.87	<0.001
Conspiracy [High]	0.57	0.50 – 0.66	<0.001

Table 3. Odds Ratios (ORs) estimated by a CLM regression* on WTV.

**reference category: wave 1st, age-class [18-34], gender [Male], educational level [Low], employment status [Unemployed], chronic disease [No], direct COVID-19 contact[No], economic concern [≤ 5], vaccination propensity [Low], supporting public health policies [≤ 5], COVID-19 perceived risk [Low], negative affective states [Low], protective behavior [Low], trust in media information sources [Low], trust in health information sources [Low], frequency of use of media information sources [Low], trust in health institution [Low], conspiracy [Low].*

Table 4 reports the results of the two models estimated for COVID-19 hesitancy due to a post-positive reluctance or a free-riding intention. In the first model, there was a slightly increased hesitancy in the second wave (+19% with respect to the first wave, 95%CI: 1.07–1.32), whereas the intention not to get the COVID-19 vaccine due to a past contagion increased with age (from [35–44] vs. <35 OR: 1.05 to [55–70] vs <35 OR: 1.39, $p < 0.001$), while a different behavior was found among those who relied on free riding (45–54 vs <35 OR: 0.79, $p = 0.006$). The educational level was not significant in the first model, while in the second one, a protective factor was exerted by a high level of education (OR: 0.84, $p = 0.022$). Females reported an increase in the intention not to get the COVID-19 vaccine because of a past contagion (OR: 1.18, 95% CI: 1.06–1.32). As observed in the WTV model, inclination to vaccination strongly predicted adherence to vaccination despite a previous contagion or a free-riding intention (OR of 0.57 and 0.42 in the first model, 0.90 and 0.54 in the second model for the comparison of high and medium vs. low class, respectively). Among the 11-dimensional scores, we considered the following in the models: 1) Negative affective states (only in the first model), 2) Protective behaviors, 3) Trust in media information sources, 4) Trust in health information sources, 5) Frequency of use of health information sources, 6) Conspiracy-mindedness, and 7) Resilience. Negative affective states, adherence to protective behaviors, trust in health information sources, and resilience exercised a protective effect on the intention not to get a COVID-19 vaccine due to both conditions. An opposite effect to vaccine uptake was associated with a high level of conspiracy-mindedness, trust in media information sources, and frequency of use of health information sources. A strong protective and progressive effect of the WTV was found in the cases of both post-positive reluctance and free-riding intention with higher protection levels found among those in the lowest

categories of conditional COVID-19 hesitancy (see Table S2 of the Supplementary Materials).

Variables	COVID-19 vaccine hesitancy due to (N=4671)					
	Post-positive reluctance			Free riding intention		
	OR	95% CI	P-value	OR	95% CI	P-value
Wave [2nd]	1.19	1.07 – 1.32	0.001	1.07	0.96 – 1.20	0.224
Age-class [35-44]	1.05	0.89 – 1.24	0.526	0.88	0.74 – 1.04	0.140
Age-class [45-54]	1.15	0.98 – 1.35	0.085	0.79	0.67 – 0.93	0.006
Age-class [55-70]	1.39	1.20 – 1.61	<0.001	0.87	0.74 – 1.02	0.079
Gender [Female]	1.18	1.06 – 1.32	0.003	1.04	0.93 – 1.17	0.460
Educational level [Medium]	1.02	0.90 – 1.16	0.729	0.92	0.80 – 1.05	0.208
Educational level [High]	1.13	0.98 – 1.30	0.091	0.84	0.72 – 0.98	0.022
Vaccine propensity [Medium]	0.57	0.46 – 0.70	<0.001	0.90	0.73 – 1.11	0.307
Vaccine propensity [High]	0.42	0.35 – 0.52	<0.001	0.54	0.44 – 0.66	<0.001
Negative affective states [Medium]	0.88	0.77 – 1.01	0.062	-	-	-
Negative affective states [High]	0.74	0.64 – 0.85	<0.001	-	-	-
Protective behavior [Medium]	0.97	0.85 – 1.11	0.693	0.85	0.74 – 0.98	0.025
Protective behavior [High]	0.83	0.72 – 0.96	0.010	0.76	0.65 – 0.88	<0.001
Trust in media information source [Medium]	1.23	1.08 – 1.41	0.002	1.36	1.18 – 1.58	<0.001
Trust in media information sources [High]	1.42	1.22 – 1.65	<0.001	1.55	1.32 – 1.82	<0.001
Trust in health information sources [Medium]	0.77	0.66 – 0.89	<0.001	0.83	0.71 – 0.96	0.015
Trust in health information sources [High]	0.60	0.51 – 0.72	<0.001	0.59	0.49 – 0.71	<0.001
Frequency of use of health inf. sources [Medium]	1.08	0.94 – 1.23	0.274	1.16	1.01 – 1.34	0.038
Frequency of use of health inf. sources [High]	1.33	1.14 – 1.55	<0.001	1.78	1.52 – 2.09	<0.001
Conspiracy [Medium]	1.24	1.09 – 1.41	0.001	1.29	1.13 – 1.49	<0.001
Conspiracy [High]	1.30	1.13 – 1.50	<0.001	1.42	1.22 – 1.64	<0.001
Resilience [Medium]	0.88	0.77 – 1.00	0.055	0.90	0.79 – 1.04	0.155
Resilience [High]	0.84	0.73 – 0.95	0.008	0.67	0.58 – 0.77	<0.001

Table 4. Adjusted* Odds Ratios (ORs) estimated by two separate CLM regressions on the vaccine hesitancy due to post-positive reluctance and free riding intention.**

*adjusted for the Willingness To be Vaccinated (WTV) taken as continuous in a nominal form (see supplementary materials Methods S2 and Table S2).

**reference category: Wave 1st, Age-class [18-34], Gender [Male], Educational level [Low], Vaccine propensity [Low], Negative affective states [Low], Protective behavior [Low], Trust in media information source [Low], Trust in health information sources [Low], Frequency of use of health information sources [Low], Conspiracy [Low], Resilience [Low].

4. Discussion

4.1 *Factors affecting WTV*

In line with the growing literature on the topic, our data confirmed several predictors of COVID-19 vaccination intention. An increased WTV was associated with older age (Daly et al., 2021; Lazarus et al., 2020; Malik et al., 2020; KFF COVID-19 Vaccine Monitor - April 2021; Murphy et al., 2021; Robertson et al., 2021; Schwarzinger et al., 2021; Seale et al., 2021; Soares et al., 2021), higher education level (Daly et al., 2021; Lazarus et al., 2020; Malik et al., 2020; Robertson et al., 2021; Schwarzinger et al., 2021), being a health worker (Gagneux-Brunon et al., 2021; Maltezou et al., 2021), having a chronic health condition (Schwarzinger et al., 2021; Seale et al., 2021; Soares et al., 2021), being in favor of vaccination in general (Attwell et al., 2021; Caserotti et al., 2021; Palamenghi et al., 2020; Schwarzinger et al., 2021), supporting public health policies (Soares et al., 2021), adopting recommended public health measures (Soares et al., 2021), higher risk perception (Attwell et al., 2021; Caserotti et al., 2021; Viswanath et al., 2021), trusting (Murphy et al., 2021; Palamenghi et al., 2020) and using health sources of information (Murphy et al., 2021), and trusting health institutions (Murphy et al., 2021; Viswanath et al., 2021).

Also knowing someone who has been infected with COVID-19 increased vaccination intention during the early phases of the pandemic (e.g., Schwarzinger et al., 2021), but our data show that, almost a year after the onset of the pandemic, WTV increased only for those who had known someone who died of COVID-19. Furthermore, WTV increased for participants feeling strong negative affective states, similar to previous findings showing that COVID-19-related anxiety was positively associated with vaccine acceptance (Bendau et al., 2021). Our results also showed that worry about the future economic consequences of the pandemic increased WTV. While this is in line with the results of a Portuguese study showing that loss of income during the pandemic was a positive predictor of vaccine intention (Soaes et al., 2021), other studies conducted in Germany found an inverse relationship between economic fears and vaccine acceptance (Bendau et al., 2021) or no relationship with non-pharmaceutical intervention acceptance (Rosman et al., 2021).

Reduced vaccination intentions were associated with female gender (Daly, 2021; Lazarus et al., 2020; Murphy et al., 2021; Robertson et al., 2021; Schwarzinger et al., 2021; Soares et al., 2021; Ishimaru et al., 2021; but see also Caserotti et al., 2021; Seale et al., 2021), high trust in media information sources (Murphy et al., 2021), and high conspiracy-mindedness (Murphy et al., 2021).

4.2 *Vacillation: post-positive reluctance and free-riding intention*

We also aimed at investigating which factors hinder vaccination intention among people who tested positive for COVID-19 and among those who counted on others getting vaccinated. Those who were more likely to vacillate in their COVID-19 intention had medium or high levels of trust in media information and medium or high levels of conspiracy-mindedness but also medium or high frequency of use of health information sources. The latter might be moderated by the protective role played by trust in health information sources, which is highly correlated with their use. These factors are detrimental to vaccination intention, increasing both post-positive reluctance and free riding. Additionally, older age (over 55 vs. younger than 35) and female gender increased specifically post-positive reluctance, as did answering the questionnaire later on (wave: February vs. January). It is important to note that during the first months of the vaccination campaign in Italy, it was mainly health professionals, people with high-risk medical conditions, and those over 80 who were reached, and that those infected with COVID-19 were to wait at least 90 days after the documented infection before being vaccinated.

In both instances, people were less likely to vacillate in their COVID-19 intention in cases of higher WTV, propensity for vaccination in general, adoption of recommended public health measures, trust in health information sources, and levels of resilience. Feeling high (vs. low) negative affective states is a protective factor that reduces only the post-positive reluctance, whereas free-riding intention is reduced among those with a high (vs. low) education level and among those middle-aged (45–54) and older (above 55) persons vs. younger persons (below 35).

The latter result needs to be carefully considered, as younger people are less likely to develop serious health consequences but can still spread the disease to older persons. To promote adequate adherence to vaccine campaigns, several governments have resorted to behavioral strategies specifically addressed to young people. For example, some US states have offered college scholarships or travel incentives; others have held a lottery for the vaccinated with

prizes up to million dollars, in addition to walk-ins (during which people can be vaccinated without booking) to encourage those on the fence to get vaccinated. The enthusiastic adherence to these initiatives may depend not only on the attractiveness of the conditions but also on the overt positive consequences of COVID-19 vaccination, such as getting the vaccine passport or green pass and restarting one's social life. Despite the goal of maximizing vaccination, we should carefully reflect on the ethical issues related to home incentives used to encourage vaccinations: free marijuana (Washington State, 2021), alcohol (New Jersey, 2021), and hunting shotguns (West Virginia, 2021).

Additionally, it should be pointed out that the COVID-19 pandemic has fueled conspiracy beliefs with some people questioning the safety of vaccines and viewing the incentives as "bribes." Moreover, incentives are aimed not only at the "maybes" (Attwell et al., 2021) but also at those who would have been vaccinated anyway, resulting in a large waste of resources that might be used to promote more targeted interventions to increase, for example, confidence in vaccines among vulnerable and underserved groups (Curtis et al., 2021). Further, given that convenience (e.g., free administration, ease of access, time, and place) affects uptake of the vaccine (Betsch et al., 2018; MacDonald, 2015), these resources could be used, for example, to ensure compensation for lost wages among those who take time off work to be vaccinated, or to ensure convenient vaccination times and spaces, by securing widespread access to vaccines.

While incentives are mainly directed at individuals, evidence is growing about the benefits of vaccines for the community too, although the issue is complex and dynamic (Milman et al., 2021). Protecting vulnerable people in the community is a common benefit of most vaccines, and there is some evidence that efforts to improve understanding of community immunity (e.g., Hakim et al., 2021) may increase vaccination intention (Arnesen et al., 2018; Betsch et al., 2017; Logan et al., 2018). Some studies suggest that stressing the pro-social benefits of vaccination might not be as decisive as focusing on aspects related to one's own emotions (Chou et al., 2020; Gavaruzzi et al., 2021; Tomljenovic et al., 2020). In the COVID-19 context, prosocial messages seem to be effective in promoting protective behavior (e.g., Jordan et al, 2020), but this may be driven by the protection of closer circles rather than by the community at large (Banker & Park, 2020). It remains to be determined whether the pandemic has changed the way people understand community immunity and whether it can foster vaccine acceptance.

Finally, we have all testified that the pandemic has been accompanied by an infodemic (Zarocostas, 2020), with social media often considered as one of the factors contributing to vaccine hesitancy and anti-vaccine sentiment (e.g., Basch et al., 2021), even if they can also be leveraged to promote critical thinking using pre-inoculation (Banas et al., 2010; van der Linden et al., 2021). Pre-inoculation could be effective also for a segment of hesitant people who adhere to conspiracy beliefs, as it leverages people's fear of manipulation, to alert them against misinformation (Basol et al., 2021; Lewandowsky et al., 2021; van der Linden et al., 2020).

We view these results as useful pieces of a puzzle in which psychological aspects must be considered to better understand vaccination intention.

4.3 Limitations

This study's main limitation is that we assess intention, and, while intention is considered the best predictor of behavior, there might be mediating factors between the two (Brewer et al., 2017). Another limitation is that we asked participants whether they had SARS-CoV-2 without inquiring about the timing of infection. Indeed, while we found evidence of post-positive reluctance (see Table 4), having already had COVID-19 reduced WTV, but this decrease was not statistically significant (see Table 3). This might be because people who got infected were included without being asked how long ago they had had it. As clear information about the duration of antibodies following infection is still lacking, it is possible that those who had it more recently are more reluctant to get vaccinated than those who had it earlier on in the pandemic.

5. Conclusion

Despite the constant monitoring of the efficacy of vaccines against new variants of the virus, adequate vaccination coverage undoubtedly remains one of the best weapons we have to prevent SARS-CoV-2 infection. It is therefore evident how crucial it is to know people's response to vaccination campaigns, as the context changes. The unprecedented analyses considered in this paper confirmed the importance of investigating how the predictors of post-positive reluctance and free-riding intention affect COVID-19 vaccine hesitancy.

Acknowledgments

Acknowledgments are due to Katrine Bach Habersaat and Martha Scherzer (Insights Unit, World Health Organization Regional Office for Europe, Copenhagen, Denmark); they tirelessly developed the European project and ensured valuable support for the conduct of the survey in Italy. Thanks are due to Roberta Ghidoni (Scientific Director, IRCCS Fatebenefratelli, Brescia) for the enthusiasm she put into this initiative: her strong commitment was a key factor in allowing the survey to take off. Carlo Mango, Diana Pozzoli, and Beatrice Fassati (Fondazione CARIPLLO, Milan) provided an invaluable support, which made the survey possible. Twenty years after our initial close collaboration in the framework of the World Mental Health Survey Initiative, Vilma Scarpino and Valeria Reda (BVA-Doxa, Milan) guaranteed perfect planning and organization of the fieldwork and took care of many requests from the participating researchers. Finally, Gustavo Calcagno Baldini made possible the initial contacts with some of the institutions involved in the project.

Funding: This work was supported by Fondazione Cariplo (grant n° 2020-5195), the Italian Ministry of Health (*Ricerca Corrente*), and IRCCS Centro San Giovanni di Dio Fatebenefratelli institutional resources.

Declaration of competing interests

All authors declare that they have no competing interests to be disclosed.

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