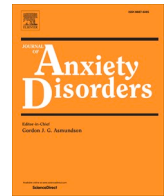




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# Fear of COVID-19 predicts vaccination willingness 14 months later

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## ABSTRACT

Vaccines are an important tool for governments and health agencies to contain and curb the Coronavirus Disease-19 (COVID-19) pandemic. However, despite their effectiveness and safeness, a substantial portion of the population worldwide is hesitant to get vaccinated. In the current study, we examined whether fear of COVID-19 predicts vaccination willingness. In a longitudinal study ( $N = 938$ ), fear for COVID-19 was assessed in April 2020 and vaccination willingness was measured in June 2021. Approximately 11% of our sample indicated that they were not willing to get vaccinated. Results of a logistic regression showed that increased fear of COVID-19 predicts vaccination willingness 14 months later, even when controlling for several anxious personality traits, infection control perceptions, risks for loved ones, self-rated health, previous infection, media use, and demographic variables. These results show that fear of COVID-19 is a relevant construct to consider for predicting and possibly influencing vaccination willingness. Nonetheless, sensitivity and specificity of fear of COVID-19 to predict vaccination willingness were quite low and only became slightly better when fear of COVID-19 was measured concurrently. This indicates that other potential factors, such as perceived risks of the vaccines, probably also play a role in explaining vaccination willingness.

## 1. Introduction

The Coronavirus Disease-19 (COVID-19) pandemic is one of the most devastating public health crises of modern times. Besides the more than five million official deaths and 200 million confirmed cases up until November 2021 (Dong et al., 2020), governments across the world have also imposed strict and invasive policies to reduce the spread of the virus, including lockdowns and curfews (Hale et al., 2021). Unsurprisingly, this pandemic has brought about major issues such as economic decline, overburdened healthcare systems, and mental health problems (Galea et al., 2020; Miller et al., 2020; Park et al., 2020).

One major tool for governments to contain and curb the spread of COVID-19 is vaccination. The first vaccine against the SARS-CoV-2 virus (i.e., Pfizer-BioNTech) was approved for use in early December 2020 in the United Kingdom and since then different vaccines have become widely available in most countries. The four vaccines approved for use in most Western countries (i.e., Pfizer-BioNTech, Moderna, AstraZeneca, and Johnson & Johnson) have been shown to be both effective in preventing severe COVID-19 disease symptoms (Sadoff et al., 2021; Tenforde et al., 2021; Voysey et al., 2021) and show an acceptable safety profile (Barda et al., 2021). Nonetheless, not everyone is willing to get

vaccinated. For example, a survey conducted in July and August 2020 by the market research company IPSOS among 19519 adults found that approximately 1 in 4 individuals worldwide were unwilling to be vaccinated (Boyon, 2020). Moreover, actual vaccination rates differ widely across countries and are typically lower than 90% (Mathieu et al., 2021), indicating that a non-trivial proportion of the population is unwilling to get vaccinated (Sallam, 2021). This is a problematic issue not only for the health of the unvaccinated portion of the population, but also for effectively containing the pandemic and preventing the emergence of novel virus strains that may worsen or prolong the pandemic (Rella et al., 2021).

Hence, an important challenge for behavioral science is to uncover the psychological mechanisms of vaccination hesitancy and to develop interventions to increase vaccination willingness (Brewer, 2021). According to several theoretical models, such as protection motivation theory and the health belief model, health behaviors are motivated by perceived threat and vulnerability (Rogers, 1975; Rosenstock, 1974). That is, according to these models, people are more willing to get vaccinated if they perceive COVID-19 to be a threat to their own health or the health of their loved ones. In emotional terms, such threat perceptions are typically expressed as the emotion fear. It is often this

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emotional reaction, rather than the cognitive risk assessment per se, that drives health behaviors (Loewenstein et al., 2001). Several researchers have identified fear of COVID-19 as a unique construct, independent from broader anxious personality traits (Ahorsu et al., 2020; Asmundson and Taylor, 2020; Mertens et al., 2020).

In line with the predictions of protection motivation theory and the health believe model, risk perceptions and fear have indeed been found to predict health-related behaviors, such as social distancing, wearing face masks, and hand washing, in the context of the COVID-19 pandemic (Harper et al., 2020; Musche et al., 2020; Yildirim et al., 2021). Similarly, several recent cross-sectional studies found that fear of COVID-19 is positively related to vaccination willingness (Bono et al., 2021; Gagneux-Brunon et al., 2021; Vollmann and Salewski, 2021; Willis et al., 2021). Nonetheless, to establish a causal connection, longitudinal and experimental studies are required. However, according to a recent systematic review of the available studies on this topic, no study so far has investigated whether fear of COVID-19 longitudinally predicts vaccination willingness (Galanis et al., 2021).

To examine whether fear of COVID-19 is indeed a longitudinal predictor of vaccination willingness, we used the data of a longitudinal study investigating levels of fear of COVID-19 (Mertens et al., 2020). This study was initiated in April 2020 and consisted of regular assessments of fear of COVID-19 and other relevant constructs over a period of 14 months in an international sample of 2000 participants. At the last measurement point (i.e., in June 2021), participants were, in addition to the constructs assessed at the other timepoints, also asked about their vaccination willingness (i.e., whether they had been vaccinated or planned to get vaccinated). Hence, using this data, the current study examines whether fear of COVID-19 at the beginning of the pandemic can predict vaccination willingness 14 months later.

To control for shared variance with fear of COVID-19, several potential confounding variables were considered. Particularly, several anxious personality traits were measured and controlled for in the analyses. These anxious traits included intolerance of uncertainty, worrying, and health anxiety. Intolerance of uncertainty refers to a dispositional trait to find uncertain situations highly unpleasant (Buhr and Dugas, 2002). Furthermore, worrying refers to a tendency to have repeated and catastrophic thoughts (Meyer et al., 1990). Finally, health anxiety refers to the tendency to misinterpret benign physical symptoms and believe that one has or is acquiring a serious illness (Salkovskis et al., 2002). Each of these constructs has been previously linked to, but distinguished from, fear of COVID-19 (Mertens et al., 2021). They were also included in the current study as control variables to establish the unique role of fear of COVID-19 in predicting vaccination willingness. Furthermore, several demographic variables (i.e., gender, age, and level of education) were taken into account, given that these variables have previously also been linked to fear of COVID-19 and vaccination willingness (Bono et al., 2021; Broche-Pérez et al., 2020). Finally, several other variables (i.e., self-rated health, previous infection, risks for loved ones, ability to prevent infection, and media use) were also included due to these variables having been previously related to fear of COVID-19 and because of their theoretical importance. That is, self-rated health, previous infection, and risks for loved ones are all directly relevant for the risk perception of COVID-19 (Yildirim et al., 2021). Perceived ability to prevent infection was included because it relates to self-efficacy beliefs (i.e., a person's belief in their ability to exert control over a situation or their own behaviors), which is a relevant factor in several psychological models of health behavior (Maloney et al., 2011; Schwarzer, 2008). Finally, media use was included because many prior studies have demonstrated a link between media use and fear of COVID-19 (e.g., Chao et al., 2020; Sasaki et al., 2020).

Finally, besides investigating whether fear of COVID-19 predicts vaccination willingness, it is also of interest whether vaccination status had an impact on fear of COVID-19. Particularly, those participants who indicated that they have already been vaccinated against COVID-19 in June 2021 may show lower levels of fear of COVID-19, given that they

may perceive their risk of becoming seriously ill due to COVID-19 to be substantially lowered. This is of interest because fear of COVID-19 has been related to increased rates of anxiety, depression and stress (Rodríguez-Hidalgo et al., 2020; Satici et al., 2020). As such, vaccination may be a way to lower fear of COVID-19 and thereby lower psychological distress and improve mental wellbeing. Therefore, we also investigated whether vaccination status had an impact on fear of COVID-19.

## 2. Methods

### 2.1. Participants

Participants for this study were recruited through Prolific platform and were compensated according to the standard rates (i.e., £7.5/h). In the first wave of the study 2000 participants took part. The study was repeated every month between April 2020 and August 2020. One additional follow-up wave was completed in June 2021, in which participants also provided information about their vaccination willingness. The data from the participants who completed both the first and the last wave of data collection (N = 938) was used for the current study. Table 1 provides an overview of the demographic information of the sample. As shown, most of the participants were equal to or younger than 40 years old (77.1%), highly educated (60.2% had at least a college degree) and reside in Europe or North America (95.9%). The Ethics Review Board of the School of Social and Behavioral Sciences of Tilburg University approved the procedure of this study (RP169).

**Table 1**  
Demographic information of the respondents (total N = 938).

	N	%
<b>Age in years</b>		
18–20	99	10.6%
21–30	380	40.5%
31–40	244	26.0%
41–50	120	12.8%
51–60	64	6.8%
61–70	28	3.0%
71–80	3	0.3%
<b>Gender</b>		
Men	451	48.1%
Women	485	51.7%
Prefer not to say	2	0.2%
<b>Education</b>		
Less than high school degree	22	2.3%
High school degree	174	18.6%
Some college, but no degree	178	19.0%
College (2-years)	72	7.7%
College (4-years)	314	33.5%
Master's degree	161	17.2%
Doctorate (PhD or equivalent)	17	1.8%
<b>Working in healthcare</b>		
No	874	93.2%
Yes (doctor)	8	0.9%
Yes (nurse)	7	0.7%
Yes (support staff)	28	3.0%
Unsure/other	21	2.2%
<b>Region of residence</b>		
Asia	3	0.3%
Europe (incl. Russia)	691	73.7%
Middle East (incl. Israel)	6	0.6%
North America	208	22.2%
Oceania	17	1.8%
South America	5	0.5%
Sub-Sahara Africa	8	0.9%

## 2.2. Materials & procedure

### 2.2.1. Measures

**2.2.1.1. Fear of COVID-19.** Fear of COVID-19 was measured using the Fear of the Coronavirus Questionnaire (FCQ; (Mertens et al., 2020). Participants were asked to indicate the extent to which they agree with eight statements on a 5-point Likert scale. Examples of the items are “I am very worried about the coronavirus”, “I am taking precautions to prevent infection (e.g., washing hands, avoiding contact with people, avoiding door handles)”, and “I am constantly following all news updates regarding the virus”. As prior work has demonstrated the reliability and one-dimensionality of the FCQ (Mertens et al., 2020), here the construct fear of COVID-19 was operationalized as the sum of the eight items of the FCQ (range = 8–40). Higher scores on the FCQ indicate higher levels of fear of COVID-19. The internal consistency was 0.74 in the current sample (April 2020 data), which is comparable to what has been found in previous studies using this scale (Mertens et al., 2020, 2021).

**2.2.1.2. Intolerance of uncertainty scale.** Intolerance of uncertainty (IU) was measured using the short scale developed and validated by Carleton, Norton, and Asmundson (Carleton et al., 2007). IU assesses and individuals' propensity to finding uncertain situations as unpleasant. The short IU scale asks participants to respond to 12 statements on a 5-point Likert scale. Examples of the statements are “Unforeseen events upset me greatly”, “It frustrates me not having all the information I need”, and “Uncertainty keeps me from living a full life”. This scale has been demonstrated to have good convergent and discriminant validity (Carleton et al., 2007) and has shown promise as a transdiagnostic assessment tool in anxiety and depressive disorders (Boswell et al., 2013; Rosser, 2019). The internal consistency of this scale was excellent in the current sample (Cronbach's alpha = 0.89; April 2020 data).

**2.2.1.3. Penn State Worry Questionnaire.** The Penn State Worry Questionnaire (PSWQ) was used to measure participants' tendency to worry. The PSWQ is a well-validated questionnaire often used within clinical setting for detecting pathological worry in adults (Meyer et al., 1990). In this study we used a shortened version asking participants to respond to eight items on a 5-point Likert scale (Crittendon and Hopko, 2006). Examples of items are: “My worries overwhelm me”, “Many situations make me worry”, and “I know I should not worry about things, but I just cannot help it”. The abbreviated version of the PSWQ has good psychometric properties (Kertz et al., 2014). The internal consistency of this scale was excellent in the current sample (Cronbach's alpha = 0.95; April 2020 data).

**2.2.1.4. Short Health Anxiety Inventory.** The Short Health Anxiety Inventory (SHAI) was used to evaluate participants' tendency to worry about their health (Abramowitz et al., 2007; Salkovskis et al., 2002). Participants were asked to respond to 18 four-choice questions on an ordinal measurement level. An example item is: “1 = I do not worry about my health; 2 = I occasionally worry about my health; 3 = I spend much of my time worrying about my health; 4 = I spend most of my time worrying about my health”. Typically, this scale is subdivided into two subscales: concerns about illness likelihood (14 items) and illness severity (4 items). We have followed this convention in the current study by summing the item scores separately for both constructs. Previous studies have shown that this scale has a stable factor structure and good psychometric properties (Alberts et al., 2013). The internal consistency was 0.90 for the illness likelihood subscale and 0.71 for the illness severity subscale (April 2020 data).

**2.2.1.5. Media use.** To measure participants' voluntary exposure to news about the coronavirus, they were asked to answer the following

question: “Have you looked up any extra information regarding the corona virus outbreak? (not taking into account coincidentally seeing/reading about it in the news)” with yes or no. Additionally, participants were asked to indicate which information sources they had used (i.e., “Regular newspapers/websites/TV news”, “Social media (Facebook, Twitter, Instagram, ...)”, “Professional websites (health institute, blogs posted by virologists/biologists, ...)”, “Friends/family/acquaintances”, “Online searches (e.g., through Google, Bing, Ecosia, etc.)”, “Other (please specify)”; multiple answers were possible) and whether they had paid attention to the source of the media outlets using a 5-point Likert scale (1 = “Strongly agree”, 5 = “Strongly disagree”).

**2.2.1.6. General health, risk control and risk for loved ones.** Participants were also asked to rate their general health, their perceived control to prevent being infected, and the perceived risk for their loved ones. Particularly, they were asked to answer the following question regarding their health: “Overall, I would rate my general health as:” (options: “Extremely good”, “Somewhat good”, “Neither good nor bad”, “Somewhat bad”, “Extremely bad”). Perceived control of preventing infection was assessed with the following question: “Overall, I believe that I can control or avoid becoming infected by the coronavirus (e.g., by limiting social contact, washing hands, wearing a face mask, etc.)” (options: “Strongly agree”, “Somewhat agree”, “Neither agree nor disagree”, “Somewhat disagree”, “Strongly disagree”). Finally, risk perception for the participants' loved ones was assessed with the following questions: “Overall, I believe that people that I care about (e.g., grandparents) are at risk of becoming infected and seriously ill due to the coronavirus outbreak:” (options: “Strongly agree”, “Somewhat agree”, “Neither agree nor disagree”, “Somewhat disagree”, “Strongly disagree”). Please note that for the operationalization of concrete and unambiguous constructs, such as the constructs mentioned within this section, the use of single item measures is considered valid (Allen et al., 2022; Bergkvist and Rossiter, 2007) and common practice (e.g., (Eder et al., 2021)). The used questions were devised for the current study for feasibility reasons (i.e., survey length) and no existing published options.

**2.2.1.7. Demographic information.** As demographic predictors, participants were asked to indicate their gender they identify with the most (“male”, “female”, “prefer not to say”), their age (in decades), their education level (i.e., their highest degree obtained), whether they work in health care (i.e., “yes (doctor)”, “yes (nurse)”, “yes (support staff)”, “no”, “unsure (please clarify)”), whether they already got infected by the virus (i.e., “yes”, “no”, “unsure”), and their country of residence.

**2.2.1.8. Vaccination willingness (June 2021 time point only).** Participants were asked to indicate whether they were already vaccinated. The following response options were available: “No, I did not receive an invitation yet”, “No, I don't want to get vaccinated”, “Other (explain)”, “Yes, the first vaccine”, and “Yes, fully vaccinated”. This way of assessing vaccination willingness is similar to other studies on this topic, which both includes the uptake of vaccination (i.e., actual vaccination) and willingness to become vaccinated when respondents have not had the chance to receive the vaccine (e.g., (Nguyen et al., 2022)).

### 2.2.2. Survey administration

The different questionnaires and items were delivered through an online survey using the Qualtrics platform (<https://www.qualtrics.com/>). The online survey could both be completed with the use of personal computers/laptops and smartphones. The complete survey consisted of 70 self-report items and took approximately 15 min to complete.

## 2.3. Data-analysis approach

In a first step, we recoded participants' answers to the question about their vaccination. Particularly, the options “No, I did not receive an

invitation yet" (n = 281; 30%), "Yes, the first vaccine" (n = 233; 24.8%), and "Yes, fully vaccinated" (n = 285; 30.4%) were recoded as indicating vaccination willingness given that they all indicate that participants do intend to get vaccinated (n = 799; 85.2%). Only the response category "No, I don't want to get vaccinated" was coded as an unwillingness to get vaccinated (n = 101; 10.8%). The response category "Other (explain)" was omitted from the analyses because this was a small (n = 38; 4.1%) and heterogeneous category. Particularly, whereas some of the participants in this category indicated a willingness to get vaccinated (e.g., "I haven't set up an appointment yet as I was infected with the virus recently."), others were more undecided (e.g., "No, I was waiting to talk to a doctor about my underlying health issues first."), and still others were more skeptical (e.g.: "No, I am waiting for the side effects to be worked out"). Thus, for the ease of interpretation, this category was not considered.

Next, a binary logistic regression was executed to predict vaccination willingness in June 2021 with fear of COVID-19, anxious personality questionnaires (i.e., intolerance of uncertainty, PSWQ, and SHAI), risk perceptions and factors (i.e., control of infection, risk for family members, and self-rated health), media use (i.e., regular media, online searches, professional media, or social media), and demographic variables measures (i.e., age, gender, education, and previous infection) in April 2020. This logistic regression was followed up with a ROC-curve analysis to examine the sensitivity and specificity of fear of COVID-19 to predict willingness to get vaccinated. In addition, we conducted the analyses again, but with the predictors measured in June 2021 to investigate whether prediction of vaccination willingness could be improved when the predictors are measured concurrently.

Finally, to examine the potential impact of vaccination on fear of COVID-19, we carried out a repeated-measures ANOVA on fear of COVID-19 scores with the within-subjects factor time (April 2020 and June 2021), the between-subjects factor vaccination status ("No, I did not receive an invitation yet", "Yes, the first vaccine", "Yes, fully vaccinated" and "No, I don't want to get vaccinated") and their interaction effect to test whether the change in COVID-19 fear between April 2020 and June 2021 differs across vaccination status. All analyses were carried out in SPSS v26 and an alpha level of .05 was used.

### 3. Results

#### 3.1. Predicting vaccination willingness using data from April 2020

The results of the logistic regression predicting vaccination willingness in June 2021 using the variables measured in April 2020 are reported in Table 2. As can be seen in this table, fear of COVID-19 was a significant predictor for vaccination willingness (OR = 1.08, 95%CI = 1.03–1.12). This result indicates that the odds for vaccination willingness increases with 8% for every one-point increase on the FCQ total score (ranging from 8 to 40). Furthermore, regular media use was a significant predictor for vaccination willingness (OR = 1.82, 95%CI = 1.09–3.05), with participants who looked additional information about the coronavirus through regular media channels having 82% higher odds of being willing to get vaccinated. The overall model fit was significant,  $\chi^2(16) = 38.08, p = .001$ , but only explained a limited amount of variance (Nagelkerke  $R^2 = 0.09$ ). To get an impression of the extent to which fear of COVID-19 is a good predictor for vaccination willingness, we carried out a ROC analysis. These results are shown in Fig. 1. The area under the curve was equal to 0.57, indicating that classification of vaccination willingness using fear of COVID-19 measured in April 2020 was better than random, but far from perfect.

#### 3.2. Predicting vaccination willingness using data from June 2021

To explore whether the prediction of vaccination willingness could be improved when using the same predictors measured concurrently (i.e., in June 2021), we carried out the logistic regression again. The results

**Table 2**

Results of a logistic regression using predictors from April 2020 to predict COVID-19 vaccination willingness in June 2021. Odds ratios > 1 indicate that higher scores on the predictor increases the odds for willingness to be vaccinated.

Variables	B	SE	Wald	p	OR	95% CI OR
Fear of COVID-19	0.07	0.02	9.98	.002	1.08	[1.03, 1.12]
Age	0.11	0.10	1.02	.313	1.11	[0.91, 1.36]
Male gender	-0.08	0.23	0.11	.737	0.92	[0.58, 1.46]
Highest degree	0.10	0.08	1.85	.174	1.11	[0.96, 1.28]
Previously infected	-0.32	0.22	2.22	.136	0.72	[0.47, 1.11]
General health	0.22	0.15	2.35	.125	1.25	[0.94, 1.66]
Control to prevent infection	-0.11	0.14	0.55	.458	0.90	[0.68, 1.19]
Risk loved ones	-0.08	0.13	0.37	.54	0.92	[0.71, 1.20]
LUI: Regular media	0.60	.26	5.20	.023	1.82	[1.09, 3.05]
LUI: Online searches	-0.44	0.27	2.75	.097	0.64	[0.38, 1.08]
LUI: Professional websites	0.43	0.26	2.75	.097	1.53	[0.93, 2.53]
LUI: Social media	-0.29	0.27	1.09	.297	0.75	[0.44, 1.29]
IUS	-0.02	0.02	1.14	.285	0.98	[0.95, 1.02]
PSWQ	0.03	0.02	1.81	.178	1.03	[0.99, 1.07]
SHAI likelihood	-0.01	0.02	0.27	.605	0.99	[0.95, 1.03]
SHAI severity	-0.10	0.06	2.96	.085	0.91	[0.82, 1.01]

Note: SE = Standard Error; OR = Odds Ratio; LUI = looked up information; IUS = Intolerance of Uncertainty Scale, PSWQ = Penn State Worry Questionnaire; SHAI = Short Health Anxiety Inventory.

of this analysis are shown in Table 3. The overall model fit was significant,  $\chi^2(16) = 93.24, p < .001$  and explained more variance than the previous model (Nagelkerke  $R^2 = 0.20$ ). As can be seen from Table 3, fear of COVID-19 was again a reliable predictor of vaccination willingness (OR = 1.11, 95%CI = 1.06–1.15). This suggests that the odds for vaccination willingness increases with 11% for every one-point increase on the FCQ total score (ranging from 8 to 40). Additionally, perceived control of being able to prevent infection, previous infection with the coronavirus, looking up information through regular media channels and professional websites, and IU were also significant predictors in this model. That is, participants who believed that they could avoid getting infected with the coronavirus were more likely to be willing to be vaccinated. Additionally, participants who got previously infected with the coronavirus were less likely to be willing to get vaccinated. Looking up additional information about the coronavirus through regular media channels and professional websites were associated with a higher willingness to get vaccinated. Interestingly, the regression coefficient for IU was negative, indicating that participants who scored higher in IU were less willing to be vaccinated against COVID-19. This is somewhat surprising, and possibly reflects concerns and uncertainty regarding the possible side-effects of the vaccines among high IU individuals. Again, we also carried out a ROC analysis to examine the sensitivity and specificity of fear of COVID-19 measured in June 2021 to predict vaccination willingness. The area under the curve was equal to 0.69. Hence, prediction of vaccination willingness was better using data from June 2021. However, there was not cut-off point where both sensitivity and specificity were acceptable (i.e., both  $\geq .8$ ).

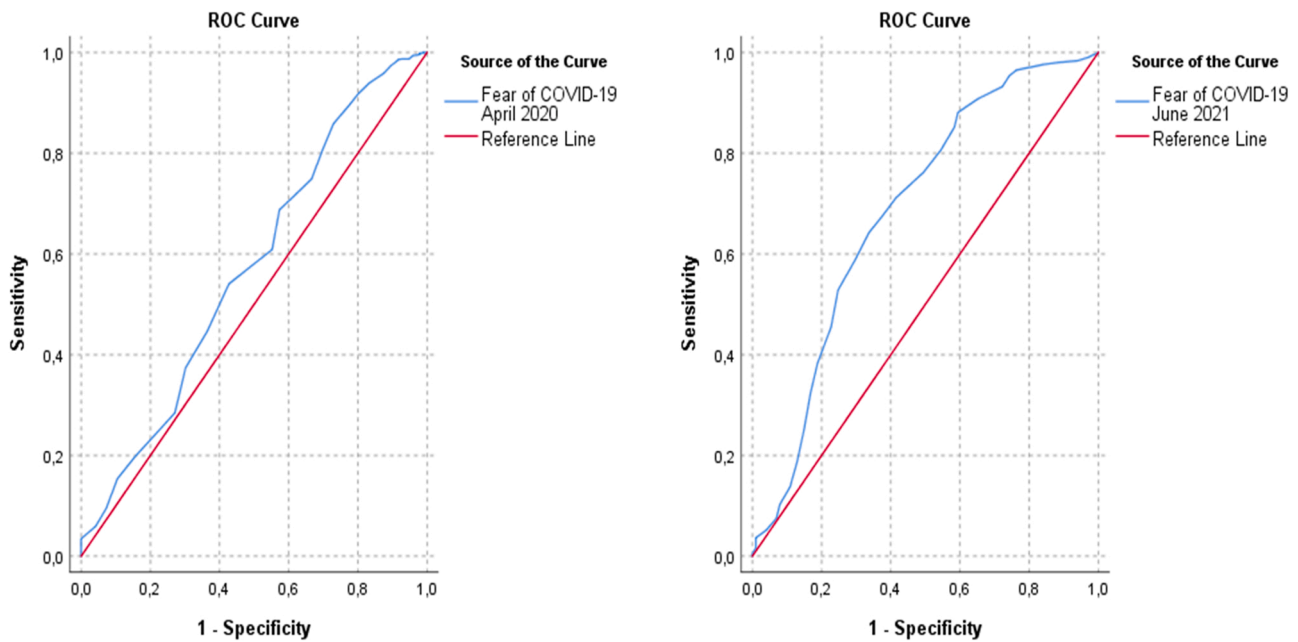


Fig. 1. ROC curves for the prediction of vaccination willingness based on fear of COVID-19 measured in April 2020 (left) and June 2021 (right).

Table 3

Results of a logistic regression using predictors from June 2021 to predict COVID-19 vaccination willingness in June 2021. Odds ratios > 1 indicate that higher scores on the predictor increases the odds for willingness to be vaccinated.

Variables	B	SE	Wald	p	OR	95% CI OR
Fear of COVID-19	0.10	0.02	23.17	< .001	1.11	[1.06, 1.15]
Age	0.06	0.11	0.33	.563	1.06	[0.86, 1.31]
Male gender	-0.09	0.24	0.13	.715	0.92	[0.58, 1.46]
Highest degree	0.12	0.08	2.33	.127	1.12	[0.97, 1.30]
Previous infection	-0.66	0.19	12.55	< .001	0.52	[0.36, 0.74]
General health	0.09	0.15	0.38	.539	1.09	[0.82, 1.46]
Control to prevent infection	0.41	0.14	9.38	.002	1.51	[1.16, 1.97]
Risk loved ones	0.06	0.12	0.28	.594	1.07	[0.84, 1.34]
LUI: Regular media	0.69	0.33	4.44	.035	1.99	[1.05, 3.78]
LUI: Online searches	-0.28	0.31	0.86	.354	0.75	[0.41, 1.37]
LUI: Professional websites	0.69	0.32	4.82	.028	2.00	[1.08, 3.71]
LUI: Social media	-0.59	0.33	3.19	.074	0.56	[0.29, 1.06]
IUS	-0.04	0.02	6.02	.014	0.96	[0.93, 0.99]
PSWQ	0.03	0.02	1.72	.190	1.03	[0.99, 1.07]
SHAI likelihood	-0.01	0.02	0.35	.555	0.99	[0.94, 1.03]
SHAI severity	-0.01	0.05	0.01	.920	1.00	[0.90, 1.10]

Note: SE = Standard Error; OR = Odds Ratio; LUI = looked up information; IUS = Intolerance of Uncertainty Scale, PSWQ = Penn State Worry Questionnaire; SHAI = Short Health Anxiety Inventory.

### 3.3. Robustness analysis

We followed-up the analyses predicting vaccination willingness with an additional robustness test. Particularly, it can be argued that the response option “No, I did not receive an invitation yet” is an ambiguous response that may include both participants who want to get vaccinated and participants who do not want to be vaccinated. As this may have influenced our results, we repeated our earlier analyses without this response option. Instead, the response options “Yes, the first vaccine” and “Yes, fully vaccinated” were combined as clear-cut options indicating vaccination willingness and contrasted with the response option “No, I don’t want to get vaccinated”. The results of these binary logistic regressions were largely identical to the initial analyses, with the exception that now both age (April 2020: OR = 1.35, 95% CI = [1.09, 1.67]; June 2021: OR = 1.28, 95% CI = [1.02, 1.59]) and education level (April 2020: OR = 1.20, 95% CI = [1.02, 1.40]; June 2021: OR = 1.18, 95% CI = [1.01, 1.39]) also emerged as significant predictors for vaccination willingness. Fear of COVID-19 remained a significant predictor for both the April 2020 (OR = 1.11, 95% CI = [1.05, 1.17]) and June 2021 analyses (OR = 1.10, 95% CI = [1.05, 1.15]).

### 3.4. The effect of vaccination status on fear of COVID-19

The repeated-measures ANOVA on fear of COVID-19 scores indicated significant main effects of both the factor time (i.e., April 2020 and June 2021),  $F(1, 869) = 582.96, p < .001, \eta_p^2 = .40$ , and the factor vaccination status (i.e., “No, I did not receive an invitation yet”, “Yes, the first vaccine”, “Yes, fully vaccinated” and “No, I don’t want to get vaccinated”),  $F(3, 869) = 15.58, p < .001, \eta_p^2 = .05$ . These main effects indicated that fear of COVID-19 decreased substantially over time and that participants who do not want to get vaccinated have lower levels of fear than the other three groups (see Fig. 2). Importantly, there was an interaction between time and vaccination status,  $F(3, 869) = 9.01, p < .001, \eta_p^2 = .03$ . Tukey’s post-hoc tests on the difference scores indicated that this interaction was due to a larger decrease in fear of COVID-19 in the group of participants who do not want to get vaccinated compared to all the other groups (see Fig. 2). The other three groups did not differ significantly in their reduction in fear of COVID-19 ( $p$ -values >.05).

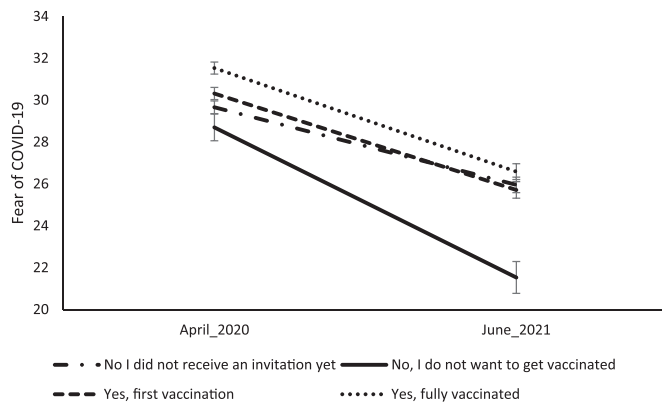


Fig. 2. Fear of COVID-19 scores in April 2020 and June 2021 as a function of participants' vaccination status.

#### 4. Discussion

In the current study we find that fear of COVID-19 is a significant predictor for COVID-19 vaccination willingness, even when measured 14 months prior to the assessment of willingness to be vaccinated and after controlling for anxious personality traits, infection control perceptions, risks for loved ones, self-rated health, media use, and demographic variables. This result suggests that fear of COVID-19 is a relevant construct to consider for explaining vaccination willingness. Additionally, perceived control of being able to prevent infection, media use, IU, age, education level, and previous infection were also significant predictors for vaccination willingness. Finally, participants who did not want to be vaccinated had larger decreases in fear of COVID-19 over time than participants who did get vaccinated or wanted to get vaccinated. These findings have implications for understanding and influencing vaccination willingness.

First, the observation that participants who had higher levels of fear of COVID-19 were more willing to be vaccinated is most likely due to participants with higher levels of fear of COVID-19 perceiving COVID-19 as a threat to their own health or the health of their loved ones. Therefore, these participants are presumably more willing to get vaccinated to protect themselves and their loved ones against COVID-19. It is interesting to note that fear of COVID-19 was a very stable predictor for vaccination willingness with a time lag of 14 months, albeit with reduced sensitivity and specificity compared to when it was measured concurrently. Based on this result, there are several potential approaches to increase vaccination willingness. One approach could be to use threat messages (or: fear appeals) to increase fear. However, the empirical evidence on the usefulness of such fear appeals to increase health behavior is mixed (Peters et al., 2013). Particularly, according to the Extended Parallel Process Model (EPPM) of fear appeals (Maloney et al., 2011; Witte, 1992), the success of fear appeals crucially depends on perceived self-efficacy (i.e., the perceived ability of a person to deal with or avoid a threat). According to the EPPM, when self-efficacy is high, fear appeals can help motivate health behaviors (such as getting vaccinated). However, when self-efficacy is low, fear appeals can result in defensive reactions and rejection of the message (e.g., when people believe that the vaccines carry potential health risks). Therefore, we recommend that public health campaigns regarding vaccination uptake should not place too much focus on fear appeals to avoid defensive reactions, but instead also place sufficient emphasis on efficacy messages. For example, recent research indicates that one of the main reasons for COVID-19 vaccination hesitancy are concerns regarding the safeness of the vaccines (Galanis et al., 2021), which presumably lowers individuals perceived self-efficacy and therefore renders fear appeals regarding the dangers of COVID-19 ineffective. Information campaigns addressing potential misconceptions regarding the safeness of the COVID-19 vaccination may be a more appropriate way to motivate vaccination

uptake than campaigns solely focusing on the dangers of COVID-19 (e.g., (Yousuf et al., 2021)). Furthermore, we additionally want to emphasize that any fear appeals or efficacy messages used should always be based on factually correct information, because exaggerated or incorrect messaging could fuel vaccine skepticism and erode public trust, which in turn are two other important factors predicting vaccination willingness (Daly et al., 2021; Lindholt et al., 2020).

Second, perceived control of being able to prevent infection, media use, IU, previous infection, age, and education level were also significant predictors of vaccination willingness. Regarding being able to prevent infection, it is possible that participants who were willing to be vaccinated saw vaccination as an effective way to prevent infection with the SARS-CoV-2 virus. This observation fits with the propositions of the EPPM and other models of health behavior that emphasize that perceived self-efficacy is an important determinant of health behavior, besides fear (Maloney et al., 2011; Schwarzer, 2008). It is worthwhile to note that, while indeed initial studies at the time of data collection suggested that vaccination could reduce one's risk of infection (e.g., (Mallapaty, 2021)), more recent studies indicates that the effectiveness of the vaccines wanes over time (Tartof et al., 2021) and that vaccination does not fully prevent against infection, especially not for the new strains of the virus (Singanayagam et al., 2021). Regarding media use, participants who reported looking up additional information about the coronavirus through regular media channels or professional websites were more willing to get vaccinated (see also (Piltch-Loeb et al., 2021)). This is most likely because these more traditional media channels considered the COVID-19 pandemic a serious threat and provided general favorable coverage of the COVID-19 vaccines, in line with the available scientific studies and advice by governmental health agencies. Interestingly, participants who looked up additional information via social media and online searches were non-significantly less willing to get vaccinated against COVID-19 (see also (Jennings et al., 2021)). Possibly, participants who looked up additional information through these channels tended to retrieve information that minimized the COVID-19 pandemic and contained more negative sentiment regarding the COVID-19 vaccines, and were therefore more hesitant to be vaccinated (see (Wilson and Wiysonge, 2020)). However, the causal connection may also be the other way around (i.e., participants who are skeptical about the seriousness of the COVID-19 pandemic and/or the effectiveness of the vaccines may more often look for confirmatory information online or via social media channels), or even bidirectional. Furthermore, surprisingly, higher IU was related to a lower willingness to be vaccinated. This is a somewhat unexpected finding because we had anticipated that higher anxious traits would predict higher vaccination willingness. Possibly, this finding relates to uncertainty about the possible side-effects of the COVID-19 vaccines. Nonetheless, this is a speculative interpretation and requires further research, given that we did not collect data regarding participants' concerns about the COVID-19 vaccines. Another predictor for vaccination willingness was a previous infection with the SARS-CoV-2 virus. Particularly, participants were less likely to be willing to be vaccinated if they had a previous infection with the SARS-CoV-2 virus. This is probably because participants were aware of the fact that immunity against the SARS-CoV-2 virus is also built up after a natural infection (Dan et al., 2021). Finally, both age and education level positively predicted COVID-19 vaccination willingness in the robustness analysis. These findings replicate the findings of earlier cross-sectional studies (Bono et al., 2021; Gagneux-Brunon et al., 2021; Willis et al., 2021). Most likely, age is related to vaccination willingness given that age is one of the main risk factors for serious illness or death due to COVID-19 (Esai Selvan, 2020). Furthermore, education level may be related to COVID-19 vaccination willingness due to higher educated participants being better informed about the dangers of COVID-19 and the benefits of vaccination (Bono et al., 2021).

Third, regarding the impact of vaccination status on fear of COVID-19, we found that participants who did not want to be vaccinated

generally had lower levels of fear of COVID-19. This corresponds with our main finding that fear of COVID-19 is related to vaccination willingness. In addition, fear reduced more throughout the course of the pandemic for participants who did not want to get vaccinated than for any of the other groups. Hence, differences between the group of participants who did not want to get vaccinated and the rest of the participants became more pronounced throughout the pandemic. This may possibly reflect radicalization and cognitive biases (e.g., confirmation bias) in the group of participants who do not want to be vaccinated, which are possibly driven and maintained by social media use (Azarpanah et al., 2021; Baines et al., 2021). The other three groups did not differ significantly from one another in changes of fear of COVID-19, suggesting that receiving the vaccine in the group of participants who were willing to get vaccinated did not significantly reduce fear of COVID-19.

One aspect of our results that warrants some further consideration is that fear of COVID-19 was a reliable, but relatively inaccurate predictor for vaccination willingness. That is, ROC analyses indicated that it was not possible to determine a cut-off point of fear of COVID-19 to increase both the sensitivity and specificity to predict vaccination willingness to acceptable levels (i.e.,  $\geq .8$ ). This indicates that other factors besides fear of COVID-19 are also important in determining vaccination willingness. Some of these other factors were identified in the current study (i.e., perceived control of being able to prevent infection, previous infection, media use, IU, age, and education level). In addition, other factors that were not assessed in the current study are most likely also important, such as perceived risks of side-effects of the vaccines, fears related to vaccine delivery (i.e., pain, needle phobia, and immunization stress-related responses), trust in public health authorities, and prosocial reasons (i.e., getting vaccinated for others who are at risk) (Böhm and Betsch, 2022; Boyon, 2020; Daly et al., 2021; Freeman et al., 2021; Galanis et al., 2021). Future studies should consider these different factors, including fear of COVID-19, to get a complete assessment of factors determining vaccination willingness.

There are several limitations to this study. A first limitation is that no nationally representative samples were used, so caution should be used when generalizing these results beyond the predominantly young and highly educated western sample used for this study. A second limitation is that fear of COVID-19 was only measured with one specific scale (i.e., the FCQ developed by (Mertens et al., 2020)). However, prior research has found that fear of COVID-19 is a multifaceted construct that also includes concerns about the socio-economic consequences of COVID, xenophobia, and stress-related symptoms (e.g., nightmares) (Mertens et al., 2021; Taylor et al., 2020). It is possible that these other facets of fear of COVID-19 are also related to vaccination willingness. A third limitation is that some of the included constructs (e.g., general health, risk control and risk for loved ones) were only measured with single items, which may hamper their validity (although see (Allen et al., 2022)). A fourth limitation is that some important variables, such as concerns about the safeness of the COVID-19 vaccines (Galanis et al., 2021), were not included in this study. Finally, a fifth limitation concerns the causal conclusions that can be drawn from this study. That is, even though this longitudinal study provides stronger evidence for the causal link between fear of COVID-19 and vaccination willingness than previous cross-sectional studies, experimental studies are needed to draw firm causal conclusions. As strengths, the longitudinal design and the relatively large sample size of this study can be noted.

Taken together, the current study shows that fear of COVID-19 is a relevant predictor for vaccination willingness. As such, fear of COVID-19 may be a relevant target to consider for increasing vaccination rates, in line with theoretical models such as protection motivation theory and the health belief model. Nonetheless, it is important for policy makers to be aware of the limitations of fear appeal messages and recent research shows that also other factors (e.g., concerns about the safety of the vaccinations) are important to consider for influencing vaccination willingness.

## Declaration of Competing Interest

The authors declare no conflict of interest regarding the research reported in this article.

## Data availability

The data of the study reported in this article can be obtained at <https://osf.io/ryndg/>.

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