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Your vaccine attitude determines your altitude. What are the determinants of attitudes toward vaccination?

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ABSTRACT

Attitudes toward vaccination are doubtless an important determinant of public health, and this became evident after the first year of the last COVID-19 pandemic. The issue, long-debated within European societies, especially with respect to occasional surges of diseases in given years, has become a crucial determinant of the wellbeing of a country since 2021. In this study, using microdata from a 2019 Eurobarometer survey, we frame and deepen our knowledge about the main determinants of vaccination attitudes as observed by the related literature. We argue that a positive attitude toward vaccination may be due to individualistic or altruistic reasons, or various incentives; our analysis aims to improve our knowledge about the determinants of such a complex decision. Our findings, obtained by means of a quantitative analysis that employs Ordered Probit, Ordered Logit and Generalized Ordered Logit estimations, provide complete support for some of the theories that have been debated in the literature, limited support for others because of mixed evidence, and no support for some.

Attitude is everything, so pick a good one.

Wayne Dyer

1. Introduction

Since the initial appearance of a new form of coronavirus infectious disease (COVID-19) in December 2019, national governments all over the world have been involved in fighting its spread. A pandemic was declared by the World Health Organization (WHO) on 11 March 2020. During the first two waves of the pandemic, governments adopted two principal types of policy: i) measures aimed at directly strengthening the capacity of the health system, and ii) measures aimed at reducing the probability of people contracting the virus, such as lockdowns and social distancing measures, which are defined by the literature as non-pharmaceutical interventions (NPIs).

In regard to the latter type of measures, several studies have tried to assess whether NPIs have been effective in reducing the spread of the virus [49]. In particular, during the first wave there was significant debate among citizens, policymakers and scholars about the social cost of such measures, and the related economic price. According to one of the first contributions in the literature, which focused on the airport lockdown imposed in China, a significantly decreased growth in new COVID-19 cases was observed [29]. Another study, adapting an SIR model to include lockdowns and virus testing, suggested that lockdowns are a government's second best option after testing [38]. These general findings were moderated by Sardar et al. [39], who, looking at the Indian case, concluded that the positive effect of lockdowns in reducing contagion rates could be observed in only some provinces. A subsequent contribution, the first to adopt a cross country perspective, concluded that a lockdown is effective in reducing the number of people infected by each person with the virus, adding that its effectiveness continues to hold up to 20 days after the introduction

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of the policy [3]. Assuming the effectiveness of such policies, on the basis of the empirical results provided by several contributions, another strand of literature has investigated which factors may be able to influence different levels of NPI effectiveness. Considering that these kinds of containment policies oblige people to make significant changes to their social behaviour, recalling troubling historical precedents [29,4] note that "how people decide to observe lockdown is crucial if the measure is to have an effective outcome" (p. 32). In particular, good governance and social values can be considered as a push factor able to positively influence individuals' compliance and the related effectiveness of NPIs [2,4].

Despite the fact that the adoption of such measures has been triggered more by the unfolding of the pandemic than by policy choices [5], it is worth noting that during the first two waves, NPIs, at least up to the start of the COVID vaccination campaign, which started in Europe on 27 December 2020, were the main instrument for national governments to deal with the spread of the virus, and conceptually were not dissimilar to the manner in which governments had to fight epidemics in the Middle Ages [6].

The WHO strongly supports the use of the approved COVID vaccines, which are able to provide a high degree of protection against getting seriously ill and dying from the disease, although so far no vaccine is 100% protective.[1] Vaccination policy is thus an important tool for national governments to reduce the spread of the virus. Moreover, vaccines are also relevant to previous findings on NPIs, since they can mitigate the negative economic consequences of social distancing. Indeed, because of the reduction of the transmission of the virus triggered by vaccination, governments can choose to relax the stringency of NPIs, without causing a surge in new cases. For this reason, good vaccine coverage is a very important target for policymakers, which helps to avoid further damage to the economy.

It is worth noting that the strategies adopted by national governments to increase vaccination coverage among the population have been quite heterogeneous over time. Specifically, three main strategies can be observed: i) vaccination based exclusively on voluntary schemes; ii) vaccination based on incentive schemes (such as vaccine passports); and iii) mandatoy vaccination.

The first strategy is what most governments adopted at the beginning of their vaccination campaigns. Successively, several governments, at different times, began to adopt incentive schemes to boost the vaccine coverage of their populations. At the end of 2021, following Israel, the first country to adopt this strategy, various European governments chose incentive schemes based on activities that would be made available only to possessors of vaccine passports, with different levels of intensity (among these: Austria, Belgium, Cyprus, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Luxembourg, the Netherlands, Portugal, Slovenia and Spain).[2] Mandatory vaccination is a strategy adopted at different levels of intensity in different countries, ranging from universal schemes to targeted categories. Austria was the first European country to adopt this strategy as a universal scheme for the entire adult population.[3]

Looking at the European case, despite intensive institutional communication at the national and supra-national level about the importance of, and benefits related to getting vaccinated against COVID-19, it is possible to observe a certain heterogeneity in the share of the vaccinated population. On the basis of available data (updated in August 2022) the coverage rates of individuals with a completed vaccination cycle vary between 91%, reported in Malta, to 29%, in Bulgaria (with a median value equal to 72%). It is worth noting that such heterogeneity also existed in the case of other diseases before the COVID-19 pandemic. As pointed out by Blank et al. [9], for vaccination against influenza, coverage rates vary between a minimum, registered in Poland, of 9.5%, to a maximum, registered in the UK, of about 29%. Moreover, these rates did not vary greatly from one season to another. As pointed out by Bechini et al. [8], the difficulty of maintaining high levels of vaccination is also due to an increase in vaccine hesitancy among European citizens.

For all these reasons, and especially as pandemics have been predicted to become increasingly common in future [1,41,26], it is important to understand what the reasons are that nudge people toward getting vaccinated (or not). Indeed, it is worth noting that there is a growing literature focused on so-called vaccination hesitancy [33,40]. We may sum up the principal findings of this literature by identifying three main sets of determinants of vaccination attitudes: Socio-Economic Status (SES), Ideology, and Information. It is also worth noting that individual factors may be the starting point from which to deepen our knowledge about attitudes toward vaccination, revealing latent motivations that push people to adopt certain behaviours with respect to vaccination policy. The aim of the present paper is to shed some light on the factors capable of influencing the decision to get vaccinated, and more specifically the attitude towards vaccination among the population of the various European countries, by means of an empirical analysis using Eurobarometer data. Our novel approach is based on modelling a more complex attitude of the agents toward vaccination, rather than the simple hesitancy that is usually considered in the literature. This concept, which we may define as the attitude of each citizen towards the possibility of getting vaccinated, is measurable as a continuous variable that goes from a negative side, where the attitude corresponds to what the literature has labelled vaccine hesitancy (which may therefore be considered a negative vaccine attitude), to a positive side on the other end of the distribution, definable as a positive vaccine attitude, which may of course be determined and influenced by a number of different variables.

To the best of our knowledge, this is the first original contribution the present study makes to the literature. Moreover, this research contributes to the related literature by addressing various lines of investigation. First, our contribution is the first, so far as we know, to consider two different dimensions that have a potentially positive impact on the attitude to vaccination; namely, one that is more focused on direct individual benefits, which we can consider as negative determinants of vaccination hesitancy, and a second dimension that is focused not only on the direct individual benefit that the vaccinated citizen derives from the decision to get vaccinated, but also on the utility derived from the existence of an altruistic dimension, linked to the fact that vaccination helps other people as well as oneself. In this study, we look for the impact on these two dimensions of several different possible explanations, or matrixes of determinants (more specifically, we included in our analysis Socio-Economic Status, Ideology, Information, and Trust).

Another important characteristic of our research is its use of survey data gathered before the pandemic, specifically in 2019. With this strategy we avoid any possible risk of inverse causality and endogeneity, which, unfortunately, cannot be excluded in previous contributions to this topic, as these may be biased by the degree of violence with which the COVID-19 pandemic has affected a given area; as is well known, its impact has been highly asymmetric around Europe. Our estimations do not suffer from this bias, for the simple reason that the data we use were gathered before the pandemic. In more detail, our findings are based on a quantitative analysis that uses a series of estimators, including

[1] https://www.who.int/emergencies/diseases/novel-coronavirus-2019/covid-19-vaccines/advice#:~:text=It%20is%20important%20to%20be,no%20vaccine%20is%20100%25%20protective. (URL consulted on 15/07/2022).

[2] https://www.euronews.com/travel/2021/10/12/green-pass-which-countries-in-europe-do-you-need-one-for (URL consulted on 15/07/2022).

[3] More information about mandatory schemes for COVID vaccination are given here: https://www.reuters.com/business/healthcare-pharmaceuticals/countries-making-covid-19-vaccines-mandatory-2021–08-16/ (URL consulted on 15/07/2022).

Ordinary Least Squares (OLS), Ordered Probit, Ordered Logit, and Generalized Logit models.

The rest of the article is organized as follows: in the next section we review the main findings reached by the literature that focuses on vaccination attitudes, and formalize the research hypothesis of the paper; section 3 describes data and methodology in greater detail; section 4 reports our main results, and section 5 provides some robustness checks. The final section, as usual, highlights our main contributions, and the conclusions of the paper.

2. Background and tested hypothesis

Vaccination is an important measure from a public health perspective. Indeed, as Bryson et al. [11] point out, vaccination has been the principal intervention of public immunization programs. This pharmaceutical measure has contributed greatly to increasing life expectancy since the start of the twentieth century [20], and is a measure for preventing deaths all over the world [48]. Accordingly, in order to increase the efficacy of vaccination campaigns, it is crucial for governments to understand what factors can explain why people tend to be willing (or reluctant) to get vaccinated. There is an important strand of literature concerned with explaining vaccination hesitancy, which, as we explained, can be seen in our framework as the negative side of vaccination attitudes. Indeed, over the last few years it has been possible to observe increasing scepticism about the benefits linked to vaccination [24,25]. This trend is also confirmed by the emergence of anti-vaccination movements, whose spread is abetted by internet culture [45,45,10].

Another important point regards the deeper reasons lying behind the choice to get vaccinated, especially in regard to the positive side of vaccination attitudes. From an egotistical perspective, individuals can choose to be vaccinated in order to reduce the risk of disease, providing private benefits linked to such a choice. At the same time, however, by adopting an altruistic perspective, people may choose to get vaccinated in order to generate collective benefits, reducing the risk of infecting others [40].

As pointed out by Siciliani et al. [40], the decision to get vaccinated depends on an individual's perception of the costs and benefits linked to this choice, and these impacts can be expressed in both financial and social terms. Various scholars have pointed out that vaccination attitudes can be triggered by several factors.

One strand of this literature has investigated socio-economic status, which can be positively correlated with pro-vaccination behaviour. The general findings seem to suggest that individuals characterized by lower socio-economic status tend to be more opposed to vaccination. Durbach [14], by means of qualitative research based on historical documents from Victorian England about the Compulsory Vaccination Act, highlights that anti-vaccination issues were absorbed by the working class, who tended to interpret the compulsory scheme as an example of class legislation. From a quantitative perspective, in their seminal paper, Cummings et al. [12] use a prospective design to detect a moderate effect of socio-economic status on participation in the swine influenza immunization campaign. Building on this framework by means of a question related to the self-perception of socio-economic status, the present paper will test the following hypothesis:

> H1. Individuals who perceive themselves as belonging to a higher social class are more likely to show pro-vaccination attitudes.

Education may also play an important role in explaining attitudes toward vaccination. Nevertheless, the results in the literature so far are neither linear nor univocal. Lazarus et al. [30], using univariate and multivariate logistic regression based on a sample of 19 countries around the world, suggest that the positive effect of education shows important differences at country level. In more detail, their results highlight on the one hand the positive effect of education on individuals' vaccination acceptance in Ecuador, France, Germany, India, and the US, while on the other hand a higher level of education was correlated with lower acceptance in Canada, Spain, and the UK. Larson et al. [28], in their study on the state of vaccine confidence in the EU, use descriptive statistics and regression analysis to suggest that in the European case, level of education is positively correlated with a positive view of vaccination in term of importance, effectiveness and religious compatibility. Nevertheless, people with the highest level of education (e.g. Masters and Ph.D. holders) do not show a positive inclination toward the importance of vaccines. This evidence seems to confirm previous findings that detect scepticism about vaccination among those with the highest level of education [21,21].

In this rationale, our study will test the following hypotheses:

> H2a. People with a higher level of education are more likely to show pro-vaccination attitudes.
>
> H2b. People belonging to the highest educational level show lower pro-vaccination attitudes than people with middle to high levels of education.

Political ideology may also explain vaccination attitudes. As pointed out by Czarnek et al. [13], the majority of these studies have investigated the US case, providing mixed evidence and results that are not univocal. On the one hand the report conducted by Kahan [27], using logistic regression and focusing on the US, does not detect any significant effect from political orientation on disagreement about childhood-vaccination risks. On the other hand, however, according to a more recent contribution made by Baumgaertner et al. [7] based on an internet survey conducted in the US, and using structural equation models, conservative individuals tend to show a lower propensity to be pro-vaccination.

It is also important to note that several studies investigating the political factors able to influence individual acceptance of vaccination highlight the central role of belief in conspiracy theory. Lewandowsky et al. [31], who investigate individuals' rejection of some scientific propositions in the US by means of a structural equation model, suggest that belief in conspiracy theories is able to explain individuals' opposition to vaccines, rather than their adherence to a free-market worldview. The findings related to belief in conspiracy theories have more recently been confirmed by Hornsey et al. [25], who also suggest a positive correlation with an individualistic/hierarchical worldview.

Moving on to the European continent, and investigating Poland in particular, Czarnek et al. [13] suggest that vaccination is a less politicized topic on this side of the Atlantic than it is in the US; indeed, according to their results, political ideology is not correlated with vaccine beliefs and attitudes.

On the basis of these mixed findings detected in the previous literature about the role of ideological factors, following Baumgaertner et al. [7], the present paper will test the following hypothesis on the European context:

> H3. On the one hand, individuals who perceive themselves as conservative are more likely to exhibit lower pro-vaccination attitudes. On the other hand, individuals who perceive themselves as progressive are more likely to exhibit higher pro-vaccination attitudes

Moreover, as has already been pointed out, it is worth noting that higher polarization in politics can be associated with vaccination hesitancy. Van Prooijen et al. [43], in their study conducted in the US, suggest that "political extremism and conspiracy beliefs are

strongly associated due to a highly structured thinking style that is aimed at making sense of societal events" (p. 570), and conclude that extreme political thought on both the left and the right is more susceptible to belief in conspiracy theories. We may thus develop our knowledge of the relationship between political polarization and vaccination attitudes in the European context by testing the following hypothesis:

H4. Individuals who perceive themselves as being more politically polarized tend to be less inclined to get vaccinated.

Information about vaccines may play an important role in explaining such behaviour, since vaccine attitudes can be the result of fear or concern [37]. In this perspective there are reasons to believe that quality and quantity of information may affect attitude towards vaccines. Following the idea that individuals who are against vaccines are mainly worried about their safety [42], according to Elliman and Bedford [15], vaccination hesitancy can be triggered by misinformation about the vaccines. On the other hand, the perception of risk can positively influence attitudes toward vaccination [35], making people more willing to accept interventions [19]. In this rationale, as pointed out by Maurer et al. [32], the level of concerns about vaccination depends on the source of information, highlighting the importance, from a policymaker's perspective, of better understanding how people ought to receive and use information. It is worth noting that communication and information strategies adopted by governments must be adequately implemented; indeed, as pointed out by Nyhanet al. [34], messages designed to reduce vaccine misperceptions may have no effect on increasing parental intent to vaccinate their children.

On the basis of the main results of the cited literature, we may test the following hypothesis:

H5. People who are better informed about the vaccine tend to be more willing to get vaccinated.

There is also an emerging interest in the literature on the effects of individual attitudes toward certain sensitive topics, such as vaccination, and their beliefs in conspiracy theory. This issue has been triggered by the effects of the use of social media and, more generally, habits in the online world, on the individual perception of topics like vaccination [40,44]. While it is very difficult to measure individual beliefs related to conspiracy theories, there are reasons to believe that conspiracy theory belief modifies individuals' behaviour in regard to trust in governments, trust in media, and life satisfaction. Indeed, a typical trait of conspiracy theory believers is their mistrust in both government and "official" sources of information; furthermore, conspiracy theorists typically have low levels of life satisfaction.

Potentially, there are therefore reasons to believe that trust in government may affect individuals' attitudes toward vaccination, as well as trust in media. If we consider that vaccination is often a public health intervention where numerous public bodies are involved, a higher level of trust can be correlated with individual approval of government-issued information and recommendations, positively influencing attitudes toward vaccination. Nevertheless, as pointed out by Siciliani et al. [40], so far the evidence regarding the role played by trust in government is weak.

In this study we will test both trust in media and trust in government by means of the following hypotheses:

H6a: Trust in media is positively correlated with vaccination attitudes;
H6b: Trust in government is positively correlated with vaccination attitudes;

It is worth noting that from a psychological perspective, life satisfaction (a variable that is generally found to be negatively correlated with anxiety and psychological disorders: [23,18] can also be correlated with paranoid and conspiracy beliefs [36]. In this rationale, life dissatisfaction can trigger negative attitudes against vaccination. As highlighted above, the strand of literature regarding conspiracy beliefs is also correlated with political ideology contributions [43]. On the basis of the cited literature, the present study will test the following hypothesis:

H7. Individuals who are more satisfied with their lives tend to have more pro-vaccination attitudes.

In conclusion, it is worth noting that each of the hypotheses presented here will be tested looking both at the "individual" and "altruistic" dimensions of the attitude toward vaccination. To the best of our knowledge this is the first contribution that tries to shed some light on these two facets of attitudes toward vaccination.

3. Data and methodology

As already explained, by means of an empirical analysis using Eurobarometer data, the present paper aims to deepen our knowledge of attitudes to vaccination by testing the hypotheses reported in the previous section.

To fulfil this aim we employed dataset ZA7562, taken from Eurobarometer 91.2 [17], which is formed of cross-sectional microdata from over 20,000 interviews undertaken with citizens from all over Europe in 2019. We used these data to estimate the following equation (1):

$$VaxAtt = \alpha + \beta_1 SocioEco + \beta_2 Edu + \beta_3 Pol + \beta_4 Inf + \beta_5 Trust + \beta_6 LS + \beta_7 Country + \varepsilon \quad (1)$$

where:[4]

- The dependent variable *VaxAtt* is an operationalization of the attitude towards vaccines of each interviewee. In this study we decided, as explained above, to investigate vaccination attitudes from two different perspectives. The choice to get vaccinated can be triggered, or at least encouraged, by two kinds of incentives, which may belong to either individual or altruistic reasoning. For this reason, we will test our hypotheses on the following two dimensions of vaccination attitudes: i) the importance of getting vaccinated for oneself and for others; and ii) the individual risk posed by the virus to people who are not vaccinated. It follows that *VaxAtt* is operationalized in two different ways, exploiting question QC8 of the original dataset. This question asks: "To what extent do you agree or disagree with the following statements?", and the respondent can rank their agreement or disagreement on a 1-to-4 scale. Statement 3 is the operationalization of our individualistic dimension, and states: "Not getting vaccinated can lead to serious health issues"; statement 4 represents the operationalization of our altruistic dimension, and states: "Vaccines are important to protect not only yourself but also others". *VaxAtt* is thus in our empirics either the agreement of the interviewee with statement 3 (labelled *Individualistic*) or with statement 4 (labelled *Altruistic*).
- *SocioEco* is a matrix of variables assessing the socio-economic status of each interviewee. It is composed of a set of dichotomous dummies, each of which is equal to 1 if the subject has the characteristic and to 0 otherwise. Among these regressors,

[4] Please note that all these variables, when appropriate, have been rescaled to have higher values corresponding to higher levels of trust, satisfaction, and so on.

the variables of main interest for testing our hypothesis regarding socio-economic status (which states that individuals belonging to a wealthier social class show a more pro-vaccination attitude) are represented by *DLow* (related to the subject identifying her or himself as belonging to a lower socioeconomic class) and *DUpper* (related to the subject identifying her or himself as belonging to a higher socioeconomic class). The omitted modality, and therefore reference modality, is middle class.

In order to improve our estimates and avoid biases due to omitted variables, we also include other covariates regarding socio-economic status. These are: *DPartner*, related to having a partner; *DChildren*, related to having children; *DWoman*, related to being a woman; and *Age 15–24*, *Age 25–39* and *Age over 55*, three dichotomous dummy variables identifying the age range of the respondent.

- *Edu* is a matrix of variables identifying a respondent's level of education. Despite unclear evidence, as described in our background section, some contributions seem to suggest that individuals with higher levels of education show more pro-vaccination attitudes [28]. We therefore controlled for this by including four dichotomous dummy variables equal to 1 if the respondent has studied up to a certain age, and to 0 otherwise. These are labelled *Secondary Edu* (for respondents that stopped their studies between the ages of 16 and 19); *Tertiary Edu* (for respondents that stopped their studies after the age of 20); and *Still in Edu* (for respondents who declare they are still in education, as it is their main occupation). Accordingly, the omitted, and reference, category is people who stopped their studies before the age of 16.
- *Pol* is a matrix of variables assessing the political self-identification of each respondent. The matrix is composed of four dichotomous dummy variables: CRX, CLX, RX and LX, identifying how the respondent positions her or himself on a 1–10 continuum from the extreme left to the extreme right. 1 and 2 identify someone as belonging to the left (LX), while 9 and 10 indicate the right (RX). Similarly, 7 and 8 identify a respondent as belonging to the centre right (CRX), while 3 and 4 indicate the centre left (CLX). The reference category is therefore the political centre. CRX and CLX allow us to test whether conservative individuals tend to show a lower propensity to be pro-vaccination [7]. Moreover, higher polarization in political scale can influence vaccine attitudes. As pointed out by Van Prooijen et al. [43], "political extremism and conspiracy beliefs are strongly associated due to a highly structured thinking style that is aimed at making sense of societal events" (p. 570). They conclude that extreme political thought on both the left and the right is more susceptible to conspiracy beliefs. For this reason, we may assume that individuals who are politically more polarized tend to be less inclined to get vaccinated. It is worth noting that this hypothesis is far removed from the so-called liberal bias identified by some of the previous literature.
- *Inf* is a variable based on *Vaccine Knowledge Index*, (labelled as Vax Know Index) an index offered by the dataset, which sums the correct answers given to questions about the vaccines, dividing the respondents into *High*, *Medium* and *Low* levels of knowledge about the vaccines.
- *Trust* is a matrix composed of two variables: *TTTMedia* (Tend To Trust Media), a dichotomous variable equal to 1 if the respondent has declared in question A3 that she or he tends to trust the media, and *TTTGovernment* (Tend To Trust to Government), which similarly assumes a value of 1 if the respondent has declared that she or he tends to trust the government.
- *LS* is a variable measuring life satisfaction, proxied through the answer to question D70, which asks: "On the whole, are you very satisfied, fairly satisfied, not very satisfied or not at all satisfied with the life you lead?" on a 1–4 scale.
- *Country* is a matrix of dichotomous dummies for each country, to control for possible country specificities and local effects.
- ε, as usual, is the error term.

Summary statistics about the variables employed are presented in Table 1.

4. Results

Following what has been presented so far, our empirical strategy relies on measuring the impact of each of the variables that have been presented on the two operationalizations of vaccine attitudes, *VaxAtt*. The causal direction we assume is presented in Fig. 1, with the use of a Directed Acyclic Graph (DAG).

It is worth recalling that, as described in Section 1, we consider two different dimensions as potentially having a positive effect on vaccination attitudes: an individual and an altruistic one. These are operationalized by exploiting two different questions, namely the degree of agreement with the following statements: i) "Not getting vaccinated can lead to serious health issues", and ii) "Vaccines are important to protect not only yourself but also others". The first (labelled "*Individualistic*") is therefore focused on the individualistic determinants of vaccination attitudes, while the second (labelled "*Altruistic*") is focused not only on the direct individual benefit but also on the utility derived by providing benefits to the rest of the society. In other words, this second variable captures a positive vaccine attitude derived from the existence of an altruistic dimension, linked to the fact that vaccination helps not only oneself, but also other people.

Given that our dependent variable is ordinal and not cardinal, we cannot assume that the distance between the modalities is equivalent. The solution usually suggested by the literature in these cases is the use of Ordered Probit or Logit estimators. Accordingly, we proceed to estimate equation (1) with these estimators; the results are presented in Table 2, with, respectively, Ordered Probit (2.1 and 2.2) and Ordered Logit (2.3 and 2.4).

Looking at the covariates representing the socio-economic status of the respondent, we find a positive and significant coefficient associated with belonging to the upper class for both the "individualistic" and "altruistic" aspect of vaccine attitudes (please note that the omitted category is middle class). However, it is also worth noting that declaring oneself as belonging to a lower social class, with respect to the middle class, does not report any statistically significant coefficient. On the basis of this result, we found some grounds to confirm H1, both if individuals look at the direct, individual effect of vaccination, and if we consider the altruistic effect of getting vaccinated. At the same time, it is important to highlight that we do not find an opposite effect (e.g., a negative and statistically significant sign) for individuals who declare they belong to a lower class.

As regards education, this seems, as expected on the basis of H2a, to exert a positive effect on vaccination attitudes, and is linked to the collective benefits derived from the choice of getting vaccinated. Indeed, we find a positive sign for all the modalities representing a higher level of education, compared to the primary level (e.g., the omitted category). It is also interesting to note that if we look at the coefficient linked to secondary and tertiary education, we find that it is growing. This result, derived, with some caution, from how the education variable is expressed in our dataset, seems to confirm H2a, and on the other hand to find no empirical support for H2b. Looking at the individualistic dimension of vacci-

Table 1
Descriptive statistics.

Label	*Obs*	*Mean*	*Std. dev.*	*Min*	*Max*
Low class	25,951	0.4115063	0.492116	0	1
Upper class	25,951	0.0783399	0.268711	0	1
Secondary Edu	25,951	0.4286925	0.4948987	0	1
Tertiary Edu	25,951	0.3550923	0.4785505	0	1
Still in Edu	25,951	0.0601518	0.2377725	0	1
CRX	25,951	0.0625409	0.2421401	0	1
CLX	25,951	0.1723633	0.3777032	0	1
RX	25,951	0.2309352	0.4214392	0	1
LX	25,951	0.0782629	0.26859	0	1
Vax Know.Index	25,951	1.371855	0.6431379	0	2
TTTMedia	25,951	0.4435667	0.4968146	0	1
TTTGovernment	25,951	0.365458	0.4815676	0	1
Life Satisfaction	25,951	3.054372	0.7368705	1	4
D.Partner	25,951	0.6517283	0.4764318	0	1
D.Children	25,951	0.358175	0.4794732	0	1
D.Woman	25,951	0.5479558	0.4977045	0	1
Age 15–24	25,951	0.0821934	0.2746644	0	1
Age 25–39	25,951	0.2001079	0.4000886	0	1
Age over 55	25,951	0.4711186	0.4991748	0	1
Individualistic	25,951	3.319525	0.804048	1	4
Altruistic	25,951	3.471812	0.7152921	1	4

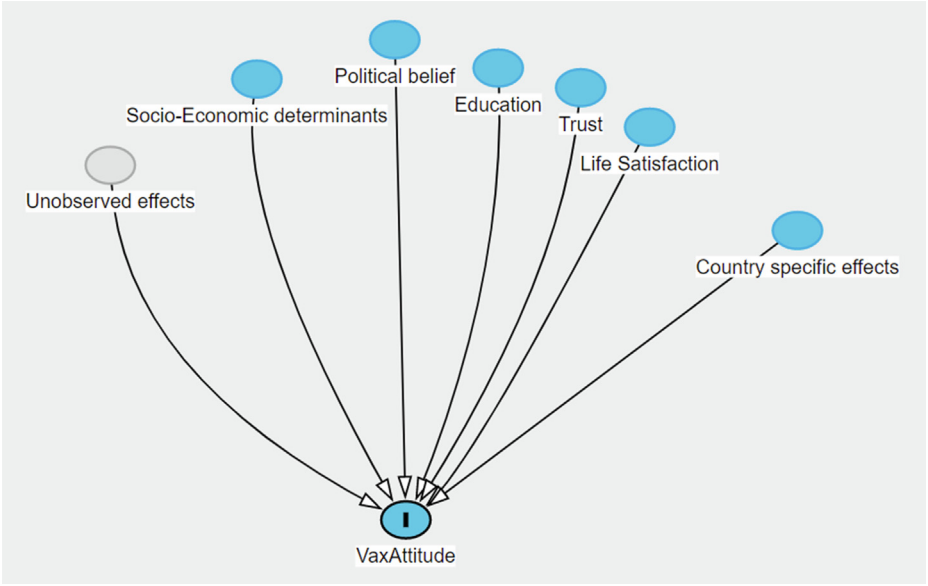

Fig. 1. Directed Acyclic Graph.

nation attitudes, H2a is the only hypothesis that is confirmed, since the only significant coefficient with the expected positive sign is that related to tertiary education, while secondary education and remaining in education do not appear to be statistically significant.

Moving on to the covariates representing the ideological factors capable of influencing vaccination attitudes, belonging to the centre-right exhibits a negative and significant coefficient only for the altruistic dimension of vaccination attitudes. This result partially confirms H3 (looking only at the collective benefits deriving from the choice to get vaccinated). On the other hand, it is interesting to note that belonging to the centre-left is positively correlated with both the altruistic and the individualistic dimensions of vaccination attitudes (with the exception of the ordered logit model for the individualistic dimension). As for the effects of polarization, most of the coefficients do not show any statistical significance.

The information exhibits the expected positive sign for all the models we estimate. This result strongly supports H5, confirming that individuals who are more informed about vaccines tend to have a positive attitude toward vaccination. This is true for both the individual and altruistic dimensions.

While trust in media gives the expected positive sign and statistical significance, fully confirming H6a, Ordered Logit and Ordered Probit models do not detect any correlation of vaccine attitude with trust in governments. Moreover, we found a positive correlation between vaccination attitude and individual life satisfaction, which is a finding that confirms H7.

Finally, it is also possible to observe other results linked to the remaining individual controls. While having a partner shows a positive correlation with individual attitudes toward vaccination for the egoistic dimension only, having children is positively correlated with both dimensions. This finding is in line with the idea that one is more altruistic once one has offspring, and also that people who have children are more altruistic, on average, than people that do not. Women, if compared to men, show higher levels of pro-vaccination attitudes in all the models, while older

Table 2
Ordered Probit (2.1 and 2.2) and Logit (2.3 and 2.4).

		(2.1)	(2.2)	(2.3)	(2.4)
		Altruistic	Individualistic	Altruistic	Individualistic
SES	Low class	0.00446	0.00540	0.00984	0.0211
		(0.27)	(0.34)	(0.35)	(0.78)
	Upper class	0.114***	0.0582*	0.220***	0.124**
		(3.52)	(1.95)	(3.82)	(2.38)
Education	Secondary Edu	0.0479**	0.0236	0.0813**	0.0393
		(2.10)	(1.07)	(2.09)	(1.05)
	Tertiary Edu	0.113***	0.0793***	0.202***	0.141***
		(4.48)	(3.26)	(4.66)	(3.41)
	Still in Edu	0.189***	0.0735	0.325***	0.131
		(3.81)	(1.55)	(3.80)	(1.62)
Ideology	CRX	−0.0656**	−0.0257	−0.0958*	−0.0216
		(-2.07)	(-0.84)	(-1.75)	(-0.41)
	CLX	0.0843***	0.0390*	0.144***	0.0542
		(3.84)	(1.88)	(3.81)	(1.55)
	RX	0.0268	0.00249	0.0703**	0.0305
		(1.39)	(0.13)	(2.13)	(0.96)
	LX	0.0340	0.0119	0.0647	0.0454
		(1.17)	(0.43)	(1.29)	(0.95)
Inf	Vax Know.Index	0.495***	0.396***	0.839***	0.688***
		(42.01)	(34.96)	(40.86)	(35.25)
Trust and conspiraciy	TTTMedia	0.0665***	0.0939***	0.104***	0.145***
		(4.11)	(6.05)	(3.76)	(5.51)
	TTTGovernment	−0.00257	0.00176	−0.0142	0.0000839
		(-0.15)	(0.11)	(-0.48)	(0.00)
	Life Satisfaction	0.0867***	0.0759***	0.156***	0.141***
		(7.50)	(6.81)	(7.82)	(7.36)
Other individual controls	D.Partner	0.0188	0.0359**	0.0315	0.0636**
		(1.10)	(2.20)	(1.08)	(2.29)
	D.Children	0.0953***	0.0449**	0.169***	0.0845***
		(5.24)	(2.57)	(5.39)	(2.85)
	D.Woman	0.0829***	0.0742***	0.141***	0.130***
		(5.47)	(5.12)	(5.44)	(5.25)
	Age 15–24	0.0561	0.0557	0.0941	0.111
		(1.34)	(1.39)	(1.32)	(1.61)
	Age 25–39	−0.0239	0.00443	−0.0437	0.00450
		(-1.07)	(0.21)	(-1.14)	(0.12)
	Age over 55	0.0737***	0.0889***	0.121***	0.151***
		(3.58)	(4.50)	(3.43)	(4.49)
	Country Fixed Effects	YES	YES	YES	YES
	cut1	−1.065***	−0.960***	−2.054***	−1.744***
		(-14.33)	(-13.56)	(-16.08)	(-14.62)
	cut2	−0.314***	−0.142**	−0.494***	−0.118
		(−4.30)	(−2.03)	(−4.03)	(−1.02)
	cut3	0.977***	0.993***	1.753***	1.804***
		(13.36)	(14.18)	(14.28)	(15.47)
	Observations	26,564	26,300	26,564	26,300
	Chi sqr	4257.2	3153.2	4265.7	3238.3
	Pseudo R2	0.0842	0.0554	0.0844	0.0569

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

individuals (e.g., people who declared they were older than 55) tend to show positive judgments about the positive effects of vaccination when compared to adults who declared they were 40–55 years old (e.g., the omitted category). Finally, younger respondents do not show any statistically significant correlation.

4.1. Robustness checks

In order to test the robustness of our findings, we decided to run other regressions using different estimators. We began by estimating equation (1) using an Ordinary Least Square (OLS) estimator. The results are presented in Table 3. In general, we can see a consistency between the signs detected in the previous regression presented in Table 2, but we also find less significant coefficients. It is worth noting that, as already explained, OLS is not the best option for dealing with these kinds of variables. The main limit of this approach, as highlighted by the literature, is that when the dependent variable is an ordered one, we cannot assume that errors are independent and identically distributed. This is why we adopted Ordered Probit and Ordered Logit estimators as baseline regressions.

At the same time, on the basis of an OLS regression we can better check for the presence of multicollinearity among the regressors, by means of a Variance Inflation Factor (VIF) test. Our results suggest a mean VIF under 2.5 (2.37 for regression 2.1 and 2.38 for 2.2), with no variables with a VIF value over 5, and therefore well under the usual threshold suggesting a problem in the estimations due to collinearity.

Finally, it is important to recognize that Ordered Logit also has its shortcomings. This model includes what is usually called "the proportional odds assumption" about the data, also known as the parallel lines assumption. In other words, the assumption is that the effect of the covariates does not vary according to the level of the dependent variable. We relaxed this assumption thanks to a Generalized Logistic Regression (GLR), which allows the effects of the independent variables to vary with the point at which the categories of the dependent variable are dichotomized. Indeed, models using GLR estimations selectively relax the assumptions of the

Table 3
OLS estimation.

		(3.1)	(3.2)
		Altruistic	Individualistic
SES	Low class	0.00216	0.00261
		(0.23)	(0.24)
	Upper class	0.0338**	0.0210
		(2.06)	(1.10)
Education	Secondary Edu	0.0272**	0.0149
		(2.11)	(1.00)
	Tertiary Edu	0.0542***	0.0431***
		(3.86)	(2.66)
	Still in Edu	0.0994***	0.0474
		(3.68)	(1.52)
Ideology	CRX	−0.0375**	−0.0203
		(−2.14)	(−1.00)
	CLX	0.0369***	0.0244*
		(3.14)	(1.80)
	RX	0.00662	−0.00820
		(0.61)	(−0.65)
	LX	0.00890	−0.00501
		(0.56)	(−0.27)
Inform.	Vax Know.Index	0.292***	0.271***
		(44.53)	(35.79)
Trust and conspiraciy	TTTMedia	0.0404***	0.0665***
		(4.54)	(6.46)
	TTTGovernment	−0.00253	0.00162
		(−0.27)	(0.15)
	Life Satisfaction	0.0494***	0.0506***
		(7.66)	(6.78)
Other individual controls	D.Partner	0.0101	0.0216**
		(1.07)	(1.99)
	D.Children	0.0495***	0.0256**
		(4.91)	(2.20)
	D.Woman	0.0440***	0.0477***
		(5.27)	(4.94)
	Age 15–24	0.0315	0.0330
		(1.37)	(1.23)
	Age 25–39	−0.0115	0.00272
		(−0.92)	(0.19)
	Age over 55	0.0458***	0.0625***
		(4.02)	(4.74)
	Country fixed effects	YES	YES
	Constant	2.828***	2.701***
		(69.13)	(57.32)
	Observations	26,564	26,300
	R^2	0.143	0.109

t statistics in parentheses* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Ordered Logit model only as needed. This allows us to produce results that do not have the aforementioned problems of the Ordered Logit model, while being almost as easy to interpret [47]. Therefore, as pointed out by [16], GLR is a useful model for confirming the results of logistic regression.

The results of the estimation of equation (1) with this technique are presented in Table 4, reporting the coefficients for each modality of the dependent variables, highlighting the ones that differ from the baseline estimation. In more detail, columns 1a and 1b report the modalities "tend to disagree", columns 2a and 2b "tend to agree", and columns 3a and 3b "totally agree". The omitted category is the modality "totally disagree". It is worth noting that in GLR positive coefficients "mean that higher values on the covariates make higher values on the dependent variable more likely" (Williams, 2006, p. 63).

While the coefficients of lower social class are still not statistically significant, two coefficients (out of six) related to upper class vary across the modalities of dependent variables.

Looking at the education matrix, there is full support for the idea that the more one is educated, the more favourable her or his attitude toward vaccination will be. This is true also with regard to knowledge about the vaccine, operationalized through the specific index offered in the dataset, for both the operationalizations of our dependent variable. At the same time, it is important to highlight that there is no support for the theory that suggests an inverse U-relationship between education and vaccine attitudes when looking at the individualistic reasons for people to get vaccinated. Indeed, in our sample, the higher the interviewee's level of education, the more favourable her or his attitude toward vaccination of an individual nature will be, as can be seen from the increasing magnitude of the coefficients. On the other hand, if we look at the altruistic operationalization of a positive attitude toward vaccination, the only statistically significant variables with respect to the education matrix are the Vaccine Knowledge index, as discussed above, and the dummy identifying agents with tertiary education. While this does not offer support to the inverse U-shaped relationship theory, it does suggest that, with respect to this kind of source of a positive attitude toward vaccinations, there is not a positive linear relationship between education and attitude to vaccination.

Moving on to the ideological variables, belonging to the centre-right shows negative coefficients for all the modalities of the altruistic dimension of attitude to vaccination, while belonging to the centre-left shows a positive and constant coefficient for all the modalities of the altruistic dimension of attitude to vaccination. Moreover, GLR allows us to add some indications regarding the effects of political polarization. For both dimensions of vaccination attitudes, extreme right-wing orientation exhibits a positive coefficient for the modality "tend to disagree", while the coefficient becomes negative for the modality "totally agree". Left-wing polarization shows a similar result for the sign of the coefficient related to the individualistic dimension of vaccination attitude. This means that polarization, both of the right and the left, exhibits the same negative correlation with greater perception of the possibility that vaccination can help to counter serious health issues. At the same time, though, only right-wing polarization presents a negative correlation with more favourable answers regarding the importance of vaccination not only for oneself, but also for others.

The positive correlation detected for the given information is confirmed in this model too, but it also allows us to add some further insights. Indeed, while the coefficients of the individualistic dimension of vaccination attitudes are constant across the modalities, we can observe higher coefficients for the modalities associated with greater consciousness about the collective benefits that derive from vaccination.

Finally, the results linked to trust in media and life satisfaction are also confirmed by the GLR. In this case too, the magnitude of the coefficients is informative. More specifically, trust in media shows coefficients higher for those modalities associated with more pro-vaccination attitudes, both at an individualistic and altruistic level. Life satisfaction shows a positive and constant coefficient for the individual dimension of vaccination attitudes, while the coefficients are positive, but marginally decreasing, if we look at the altruistic dimension of vaccination attitudes.

To sum up these findings, in Table 5 we give a summary of our results for each hypothesis presented in Section 2 and discussed in Sections 4 and 5.

5. Conclusions

COVID-19 was without a doubt the great crisis of 2020, when the entire world had to face a pandemic threat that had not been a problem in about a century. By the end of the year, mankind was able, with the distribution of the first vaccines, to set down a decisive marker in the battle to find a way out of the crisis. While initially welcomed as a solution, vaccinations soon began to be viewed with distrust and suspicion by a part of the global popula-

Table 4
Generalized Ordered Logit.

	(4.1a) Altruistic Tend to disagree	(4.2a) Altruistic Tend to agree	(4.3a) Altruistic Totally agree	(4.1b) Individualistic Tend to disagree	(4.2b) Individualistic Tend to agree	(4.3b) Individualistic Totally agree
Low class	0.0124	0.0124	0.0124	0.0246	0.0246	0.0246
	(0.44)	(0.44)	(0.44)	(0.91)	(0.91)	(0.91)
Upper class	0.258***	−0.0114	−0.329**	0.171***	−0.0665	−0.103
	(4.42)	(−0.12)	(−2.00)	(3.19)	(−0.89)	(−0.75)
Secondary Edu	0.0829**	0.0829**	0.0829**	0.0421	0.0421	0.0421
	(2.12)	(2.12)	(2.12)	(1.12)	(1.12)	(1.12)
Tertiary Edu	0.234***	0.0805	0.0295	0.178***	0.0626	−0.0487
	(5.32)	(1.34)	(0.29)	(4.17)	(1.23)	(−0.60)
Still in Edu	0.320***	0.320***	0.320***	0.130	0.130	0.130
	(3.76)	(3.76)	(3.76)	(1.62)	(1.62)	(1.62)
CRX	−0.0965*	−0.0965*	−0.0965*	0.0194	−0.116	−0.355**
	(−1.76)	(−1.76)	(−1.76)	(0.35)	(−1.54)	(−2.51)
CLX	0.142***	0.142***	0.142***	0.0557	0.0557	0.0557
	(3.76)	(3.76)	(3.76)	(1.58)	(1.58)	(1.58)
RX	0.0934***	0.00831	−0.359***	0.0867**	−0.0543	−0.501***
	(2.71)	(0.16)	(−3.85)	(2.54)	(−1.23)	(−6.34)
LX	0.0609	0.0609	0.0609	0.118**	−0.109	−0.520***
	(1.21)	(1.21)	(1.21)	(2.33)	(−1.64)	(−4.49)
Vax Know.Index	0.786***	1.010***	1.215***	0.688***	0.688***	0.688***
	(36.26)	(29.96)	(18.80)	(35.16)	(35.16)	(35.16)
TTT Media	0.0642**	0.270***	0.304***	0.102***	0.260***	0.445***
	(2.23)	(5.60)	(3.18)	(3.63)	(6.76)	(5.91)
TTT Government	−0.0138	−0.0138	−0.0138	−0.00565	−0.00565	−0.00565
	(−0.47)	(−0.47)	(−0.47)	(−0.20)	(−0.20)	(−0.20)
Life Satisfaction	0.156***	0.156***	0.156***	0.163***	0.0851***	0.0813*
	(7.83)	(7.83)	(7.83)	(7.86)	(3.11)	(1.69)
D.Partner	0.0299	0.0299	0.0299	0.0649**	0.0649**	0.0649**
	(1.03)	(1.03)	(1.03)	(2.33)	(2.33)	(2.33)
D.Children	0.166***	0.166***	0.166***	0.119***	0.0120	−0.104
	(5.31)	(5.31)	(5.31)	(3.79)	(0.30)	(−1.45)
D.Woman	0.141***	0.141***	0.141***	0.132***	0.132***	0.132***
	(5.44)	(5.44)	(5.44)	(5.32)	(5.32)	(5.32)
Age 15–24	0.0977	0.0977	0.0977	0.164**	−0.00373	−0.0723
	(1.37)	(1.37)	(1.37)	(2.32)	(−0.05)	(−0.55)
Age 25–39	−0.0430	−0.0430	−0.0430	0.00602	0.00602	0.00602
	(−1.13)	(−1.13)	(−1.13)	(0.17)	(0.17)	(0.17)
Age over 55	0.0927**	0.232***	0.258***	0.152***	0.152***	0.152***
	(2.56)	(4.52)	(2.86)	(4.51)	(4.51)	(4.51)
Constant	−1.802***	1.384***	3.260***	−2.146***	1.288***	3.272***
	(−14.22)	(6.55)	(7.54)	(−17.02)	(7.37)	(9.77)
Observations			26,564			
Chi sqr			4788.1			
Pseudo R2			0.0948			

t statistics in parentheses* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$Highlighted in green results that differ from the Ordered Logit estimation.

Table 5
Summary of the results of the analysis.

Tested Hypothesis	Model					
	Probit		Logit		Generalized Logit	
	Individual dimension	Altruistic dimension	Individual dimension	Altruistic dimension	Individual dimension	Altruistic dimension
H1 Socio Economic Status	partially confirmed	partially confirmed	partially confirmed	partially confirmed	not confirmed	not confirmed
H2a Education level	partially confirmed	confirmed	partially confirmed	confirmed	not confirmed	partially confirmed
H2b Highest education level	not confirmed	not confirmed	not confirmed	not confirmed	not confirmed	not confirmed
H3 Political orientation	partially confirmed	confirmed	not confirmed	confirmed	partially confirmed	confirmed
H4 Political polarization	not confirmed	not confirmed	not confirmed	not confirmed	not confirmed	partially confirmed
H5 Information	confirmed	confirmed	confirmed	confirmed	confirmed	confirmed
H6a Trust in media	confirmed	confirmed	confirmed	confirmed	confirmed	confirmed
H6b Trust in government	not confirmed	not confirmed	not confirmed	not confirmed	not confirmed	not confirmed
H7 Life satisfaction	confirmed	confirmed	confirmed	confirmed	confirmed	confirmed

Legend:
Confirmed: all the related coefficients exhibit the expected sign.
Partially confirmed: Only some coefficients exhibit the expected sign.
Not confirmed: the coefficients do not exhibit the expected sign (or are statistically not significant).

tion. With the help of microdata from the Eurobarometer survey about attitudes toward vaccination, in this study we tried to find determinants of negative and positive attitudes toward vaccination. We identify two principal channels through which one may take a positive attitude to vaccination: on the one hand, reasons linked to the individual gain associated with getting vaccinated, and on the other, reasons related to the collective benefits of a community due to getting vaccinated. This is of course a simplistic assumption, while reality is much more complex, and non-linearities may easily play a role. Nonetheless, our framework represents a step forward if compared with the previous literature focusing on vaccine hesitancy. On the basis of such channels, we detected two different dimensions that may affect vaccination attitudes: one closer to the direct individual benefits related to the choice of getting vaccinated (which we labelled the individualistic dimension) and one closer to the collective benefits (labelled the altruistic dimension).

To shed some light on the factors correlated with this dual dimension of attitude to vaccination, we started from the main findings present in the literature, and contributed by adding new indications, from both a theoretical and a methodological point of view. In more detail, for each dimension of vaccination attitude, we tested a number of hypotheses on this dataset regarding socio-economic status, ideology, education, trust in government and media, and life satisfaction. Our empirical analysis found support for some of the previous findings in the literature, and meanwhile identified some cases that previous results had not found, and which therefore ought to be re-considered in light of our evidence.

More specifically, we found complete support for the hypotheses concerning information, trust in media, and life satisfaction, suggesting that, with regard to both the individual and altruistic dimensions of vaccination attitude, being more informed, trusting media, and being more satisfied with one's life are correlated with a more favourable attitude towards vaccination. These results also shed some light on findings suggested by previous contributions [31,25,43] regarding the role of conspiracy beliefs in shaping individual attitudes toward vaccination.

Moreover, self-identifying as being politically centre-right or centre-left fully confirms the attitude towards vaccination assumed in the literature only for the altruistic dimension of vaccination attitude, while there is no evidence supporting it in relation to the individualistic dimension. None of the other hypotheses tested are confirmed.

These mixed results suggest the existence of different families of incentives for getting vaccinated, as we assumed, and the need for future studies to study and identify these channels more completely, overcoming the probably over-simplistic framework seen so far in the literature, with its focus on vaccination hesitancy. Since the phenomenon is complex and multifaceted, deeper investigation into its causes is required. As pointed out by Kahan [27], empirical analyses are very important to promote a better knowledge of vaccines and to design an effective risk communication.

From a policymaker's perspective, our results suggest the importance of taking into account, both at national and supranational level, the factors that are able to influence individual attitudes toward vaccination. These findings could help them, first, to understand which strategy would be most suitable to increase coverage rates, and, second, to make effective communication campaigns, which, as Bechini et al. [8] point out, must consider cultural and organization background. Such communication campaigns must also acknowledge the existence of different patterns of vaccination attitudes, depending on whether we look at the individual or the altruistic dimension. Knowledge of these differences can help us to define specific targets for communication, stressing or avoiding different aspects according to the particularities of different audience segments, and therefore achieving greater persuasiveness about the need to get vaccinated.

Although it provides further evidence and new results about several hypotheses in the literature, as well as some suggestions for policymakers, our research may be affected by certain shortcomings, which we should warn the reader about. First, it is important to highlight that our results are derived from a survey conducted in 2019 about vaccines in general. While this approach allows us to avoid biases due to the varying diffusion and mortality rates of COVID-19 in various countries, and thus prevents empirical problems in the estimations related to inverse causality and endogeneity, it is important to underline that we did not investigate the attitude towards COVID-19 vaccines specifically. While this may cause some bias in the short run if applying our research to COVID-19 vaccination, we believe that the more we go ahead with the COVID-19 vaccination campaign, the more these will be considered as "normal" vaccines, and our findings will therefore become even more solid in this regard. Second, while based on microdata and therefore on the results of a sampling operation conducted by the authors of the dataset, the population at the base of the survey was not designed by the authors with our research in mind, and may therefore be affected by sampling biases that could hinder the results. Finally, individuals are complex and non-linearities may easily be in place. Our results are based on an operationalization of the concept that may come to be seen as simplistic.

Neither author perceives a conflict of interest.

Data availability

Data will be made available on request.

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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