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Online health information seeking and Covid-19 vaccine hesitancy: Evidence from 50+ Europeans

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ABSTRACT

We use recently released data from the Survey of Health Ageing and Retirement in Europe (SHARE) to investigate the role of online health information seeking on Covid-19 vaccine hesitancy, which is defined as the reluctance or refusal to receive vaccinations despite the availability of vaccines. We adopt an instrumental variable strategy that exploits the computerization of workplaces occurred in the last century to deal with endogeneity. We find that searching for health information strongly reduces vaccine hesitancy. Results also show that individuals whose social networks suffered more during the outbreak, in terms of hospitalisations and deaths, are less likely to be hesitant. Improving individuals' technological skills might have positive spill-over effects for public health.

1. Introduction

Does looking for health information online affect beliefs about vaccines? In this paper, we address this issue by investigating the relationship between online health information seeking and Covid-19 vaccine hesitancy among 50+ Europeans.

People increasingly seek health information online. In the European Union (EU), one in two citizens does it. However, this figure varies across EU member States. In 2019, the highest share was in Finland (77 %), the Netherlands (76 %) and Denmark (72 %). In contrast, the lowest shares were in Romania (28 %) and Bulgaria (29 %) (Eurostat 2019). In Fig. A1, these statistics are contrasted with official data about vaccination rates in European countries, for what concern the uptake of the primary vaccination course. The figure depicts a positive correlation between the rate of online health information seekers in 2019 and the uptake of the primary Covid-19 vaccination course across Europe.

The recent Covid-19 outbreak has highlighted the importance of health information: due to restrictions of various type and the pressure on the healthcare systems, people had to stay at home and reduced contacts with health professionals, but increased their access to the web. A widely held view is that internet and social media are among the main causes of disinformation and vaccine hesitancy, defined as the delay in the acceptance or the refusal of vaccines despite their availability [17, 25]. Vaccine hesitancy arises from a diverse array of factors, such as the mandatory nature of vaccines, their potential coincidental association with adverse health effects, limited knowledge about vaccine-preventable diseases, and a lack of trust in both corporations and public health agencies [34]. Hence, vaccine hesitancy represents a major threat to the success of national vaccination campaigns and hence to public health. In response to these concerns, social media started to take actions to limit the spread of fake news on their platforms [27,29].

This paper speaks to several studies. First, the studies analysing the relationship between online health information and the demand for healthcare utilization. The evidence is mixed. Using an instrumental variable approach, Suziedelyte [37] finds that searching for health information on the Internet has a positive and relatively large effect on an individual's demand for health care. On the contrary, Wagner and Jimison [39] and Suenaga and Vicente [36] do not find any evidence on the association between online health information seeking and demand for physician services.

Second, a recent body of literature has investigated the role of computer and internet usage among older persons in various aspects of their lives. For instance, internet and computer usage are shown to have a positive correlation with the preservation of cognitive functions. Green et al. [21] provide evidence that IT usage during the work life has a protective effect on the cognitive function of retirees, in particular for those people who were employed in middle-skill occupations that underwent a large-scale computerization. However, Cavapozzi and Dal

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Bianco [11] show that retirement reduces computer literacy and the frequency of internet utilization for men and women.

Finally, pre-Covid-19 studies have investigated the drivers of vaccine hesitancy both at individual and collective levels, identifying the spread of misinformation online and the lack of knowledge about vaccines as the key cause [16]. Some of these studies analyze the MMR-autism controversy that stemmed from Andrew Wakefield's fake study and found that this caused a drop in vaccine uptake both in the US and Europe [10,12]. We contribute to this literature by shedding light on the role of health information seeking during the Covid-19 pandemic and its effects on vaccine hesitancy and uptake. Indeed, as shown by Pullan and Dey [33] using data from Google Trends, the online interest in relation to a Covid-19 vaccine peaked as the pandemic has progressed; but they also find evidence of spikes in search activity in relation to anti-vaccination rhetoric in the wake of advancements in a Covid-19 vaccine.

More specific to the Covid-19 case, we also contribute to the emerging evidence on the determinants of Covid-19 vaccine hesitancy. While several studies have focused on the vaccination intentions before vaccines were broadly available [26,28], very few studies investigate this issue with post-vaccination data. These latter studies have mainly focused on the role of social media and foreign disinformation campaigns [41], institutional legacy from past-communist regimes [32] and socio-demographic factors [3]. More in general, as highlighted in a cross-country study by Piltch-Loeb et al. [30], vaccine hesitancy seems to depend on similar concerns regarding vaccines across multiple countries simultaneously, indicating the potential benefits of global collaboration in Covid-19 vaccination communications and information diffusion. However, we know of no previous study attempting to identify the causal effect of internet use for active information seeking on vaccine hesitancy.

An additional contribution of our paper is that of analyzing the role of trust in shaping beliefs about vaccines. Indeed, trust is considered a key to compliance with public and health interventions that require the cooperation among individuals. Vaccines in general are a textbook case for this. In fact, their effectiveness strongly depends on the compliance of large share of population in order to reach the herd immunization thresholds. Previous research has shown that more trusting individuals are more likely to cooperate and comply with public policies [19]. However, while recent contributions have shown that this is true also with respect to the compliance with non-pharmaceutical interventions for pandemic containment [2,9,18]. We contribute to this literature by extending the analysis to the domain of vaccines, and more specifically by investigating the connection between trust and information in relation to Covid-19 vaccine hesitancy.

The remainder of the paper is structured as follows. In Section 2, we describe the data and provide summary statistics. In Sections 3 and 4, we discuss the empirical strategy and present the results, respectively. In Section 5 we draw our conclusions.

2. Materials and methods

2.1. Data

We use data from the Survey of Health Ageing and Retirement in Europe (SHARE)[1], a longitudinal dataset collecting harmonized information about health and socio-economic status of 50+ Europeans (and Israelis) (see Börsch-Supan et al. [4] and Weber [40] for a full description).

Due to the outbreak of Covid-19 pandemic, the planned fieldwork of the face-to-face (CAPI methodology) 8th wave, started in October 2019, was interrupted in March 2020, when about 70 % of the respondents across participant countries had completed the interviews.

As a consequence, SHARE decided to implement a new a questionnaire in order to collect data on the socio-economic and health impact of Covid-19 among 50+ Europeans. The questionnaire was administrated telephonically (CATI methodology) during the two SHARE Covid-19 survey waves that took place in June–September 2020 and May–July 2021, respectively.

We combine data from the second Covid-19-specific wave, which contains information about vaccination intentions, with the information from previous SHARE waves (8-7-6) on socio-demographic characteristics, health-related information and employment histories. Our final sample consists of about 35,000 observations. The full list of variables alongside descriptive statistics is reported in Table A1.

It is worth stressing that the population covered in SHARE includes individuals aged 50 or more, who typically were more often vaccinated, but used less often online health information, compared to the general population. This explains the discrepancy between the descriptive statistics in Table A1 and the corresponding sample moments depicted in Fig. A1 (that refer to the age range).

2.1.1. Key variables

2.1.1.1. Dependent variable. Our main variable of interest is Covid-19 vaccine hesitancy. In the survey, respondents are asked: "Have you been vaccinated against Covid-19?". In case of a negative answer, a follow-up question asks: "Do you want to get vaccinated against Covid-19?". Possible answers are:

1. Yes, I already have a vaccination scheduled
2. Yes, I want to get vaccinated
3. No, I do not want to get vaccinated
4. I'm still undecided

In Fig. A2, we report the respondents' vaccination attitudes across Countries. Interestingly, these figures are well in line with trends in national vaccination campaigns. Respondents from Malta, Denmark and Sweden report higher levels of vaccination uptake. On the other side, respondents from Bulgaria, Romania and Latvia exhibit lower levels of vaccinations uptake and a higher share of hesitancy.

Following the standard definition of vaccine hesitancy, our dependent variable "Hesitant" takes value 1 if the individual does not want to get vaccinated or she is still undecided, 0 otherwise.

2.1.1.2. Explanatory variables. As a measure of online health information seeking, we use a binary variable indicating whether the respondent has searched health-related issues on the Internet since the start of the outbreak. As our variable does not contain details on the type of health-related information the individual exactly searched on the web, we provide evidence from Google Trends to shed light on how many of health-related searches during the pandemic period are actually related to Covid-19 vaccines. In Fig. 1, we plot the Google trends for online searches about Covid-19 vaccines against those for the three most common health conditions in our reference population: diabetes, hypertension and ischemia. We do this exercise for Italy, Spain, France and Germany by using their respective official languages in the search engines. The figure show that the number of searches for information about the vaccine strikingly exceed those for the other health issues, suggesting that searches on Covid-19 vaccine are likely to be the most common health issue searched by individuals in our sample.

Additionally, we control for a set of individual characteristics such as gender, age, education, household income, household size, indicator for those who never worked for pay (e.g., homemaker), whether the individual lives in a urban or rural area, self-reported health, number of chronic conditions.

Finally, we construct indicators for whether someone in the individual's social network (partner, parent, child, other household

[1] More details about SHARE are provided in Börsch-Supan, A. (2022) [5–8].

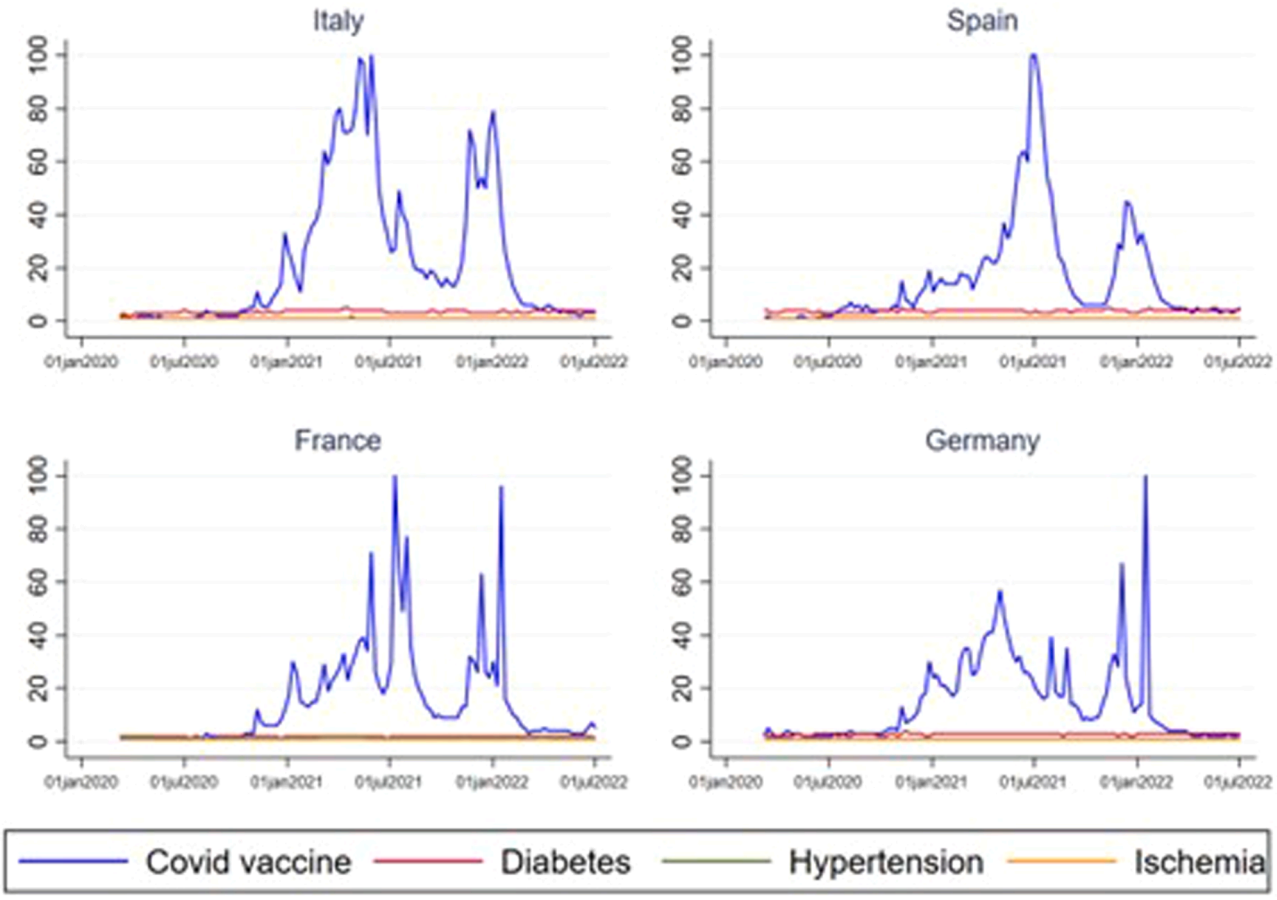

Fig. 1. Google trends.
Notes: authors' elaboration on Google Trends data.

member, other relative outside household, neighbour, friend, colleague or caregiver) has been hospitalised or died due to Covid-19.

2.1.1.3. Instrumental variables. We exploit retrospective information from previous waves of SHARE to construct the two instruments for online health information seeking. First, we use information on the individual job history for constructing a binary variable that takes value 1 if the individual has ever been required to use a computer at work before the outbreak, and 0 if she never had a job requiring the use of a computer. Second, we exploit pre-pandemic computer skills to construct an indicator which takes value 1 if the individual has any computer skill, 0 otherwise.

2.2. Empirical strategy

We aim at estimating the relationship between online health information seeking on vaccine hesitancy. However, there are many reasons why the error term and online health information seeking might be correlated, so that estimating the model using OLS will not produce a consistent estimate for the coefficient of interest. First, individuals who seek health information online might be different from individuals who do not do so, according to both observable and unobservable characteristics. Second, beliefs about vaccines might reversely determine the research for health-related information. For example, individuals who are less concerned with their own health might be less likely to go online looking for health-related information.

In order to identify the causal effect of online health information seeking on vaccine hesitancy, and to deal with these endogeneity concerns, we adopt an instrumental variable strategy. First, we leverage retrospective information on individual job history and assume that online health information seeking since Covid-19 outbreak depends on observed characteristics as well as pre-outbreak computer skills required at work. Importantly, our sample includes individuals who mainly started their careers several years before the computerization of workplaces that occurred from the 1980s onwards [21]. Thus, individuals in our sample made their career choices before knowing about the computerization rate of a specific sector and most likely they were successively asked to develop computer skills. Although, in principle, some individuals could have sorted themselves into PC-requiring jobs according to their numerical or digital attitudes, it is unlikely that these attitudes correlate with attitudes towards Covid-19 vaccines (that became available only at the end of 2020). Second, as an additional instrument, which also takes into account the computer skills of those respondents who were never into employment (i.e., homemakers), we construct an indicator taking value one if the respondent reported having any computer skill before the outbreak. Figure A3 provides a graphical representation of the (first-stage) relationship between PC-jobs and online health information seeking at the country-level aggregation.

The parameter of interest captures the causal effect of searching for health information on the internet on vaccine hesitancy. The vector the of pre-determined covariates includes the following variables: age, gender, education, income quartiles by country of residency, household size, employment status, residence in a urban or rural area, self-perceived health, number of chronic diseases, trust in others, big-5 personality traits, proxies for the subjective outbreak experience (whether someone in the respondent's social network has been hospitalised or died due to Covid-19).

3. Results

Table 1 reports the parameter estimates of online health information seeking on vaccine hesitancy. We report 2SLS estimates in columns 1–3. Columns (1) presents the estimates including both instruments, here since there are more instruments than endogenous regressors the model is over-identified. Column (2) and (3) present the 2SLS estimates by using a single instrument, either pc-job or pc-skills. Finally, column (4) reports OLS estimates, for the sake if comparison with the IV estimates shown in columns (1)–(3).

The 2SLS estimates reported in column (1)–(3) show that online health information seeking is strongly significant with a negative sign. In column (1), the coefficient is −0.104 ($p < 0.001$). This implies that online health information seeking reduces vaccine hesitancy by about 10 percentage points. Parameter estimates from OLS, in column (4), show that individuals, who searched for health information online since the start of the Covid-19 outbreak, are less likely to be hesitant towards vaccination (coef.: −0.026, $p < 0.001$).

At the bottom of Table 1, we report the first stage *F*-statistic and the Sargan–Hansen test of the over-identifying restrictions for the specification in column (1). On the basis of these statistics, we can conclude the instruments are not weak and we cannot reject the over-identification restrictions, as the p-value of the test is 0.309.

As we are also interested in investigating the other determinants of vaccine hesitancy, we now move to discuss the parameter estimates concerning the other explanatory variables. For ease of exposition, we graphically report the results of most relevant ones in Fig. 2, alongside 95 % confidence intervals. The full list of parameter estimates is provided in Table A2 in the Appendix.

Fig. 2 shows that the covariates are associated with vaccine hesitancy as might be expected. In particular, age, income and education have a negative association with vaccine hesitancy, while household size has a positive one. With respect to the health-related covariates, the number of chronic conditions is negatively associated with hesitancy, while the association with self-reported health status (SRHS) appears to be non-linear. The trust coefficient is negative and statistically significant (coef.: −0.027, $p < 0.001$). This indicates that individuals exhibiting a higher level of trust are less likely to be hesitant towards vaccination. Finally, it is interesting to notice that the subjective Covid experience, which is proxied by whether someone in the social network of the respondent has been hospitalised (coef.: −0.031, $p < 0.001$) or died (coef.: −0.023, $p = 0.002$) due to Covid-19, is negatively associated with vaccine hesitancy, and this effect is highly significant.

Table 1
Effect of health information seeking on vaccine hesitancy.

	(1) Hesitant 2SLS	(2) Hesitant 2SLS	(3) Hesitant 2SLS	(4) Hesitant OLS
Online health info	−0.104***	−0.116***	−0.099***	−0.026***
	(0.012)	(0.017)	(0.013)	(0.004)
Controls	Yes	yes	yes	yes
Country FE	Yes	yes	yes	yes
Obs.	34,309	34,309	34,309	34,309
R^2	0.173	0.171	0.172	0.181
Instruments	PC job + PC skills	PC job	PC skills	
First stage *F*-statistic	2562.747	2500.303	4469.406	
Sargan–Hansen (*p*-value)	1.035 0.309			

Notes: The table repots the parameter estimates. Full list of covariates included. Standard errors in parentheses. ***, **, * indicate significance at 1 %, 5 % and 10 %, respectively.

3.1. Robustness checks

3.1.1. Plausible exogeneity

There are several concerns regarding the validity and exogeneity of instrumental variables. Here, we relax the assumption that our instruments are not correlated with other unobserved factors that influence vaccine hesitancy, and instead propose that the instrument can be considered as "plausibly exogenous". We follow the approach by Conley et al. [13], who consider the just-identified case and show how the parameter of interest changes when relaxing exogeneity, by allowing the instrument to have a direct - near zero - effect on the outcome.

Conley et al. [13] propose two distinct approaches: the local-to-zero (LTZ) approach and the union-of-confidence intervals (UCI) approach. We report the parameter estimates using the LTZ approach in Table 2, while we show in Fig. A4 the estimated bounds following the UCI approach. We see that the LTZ estimates are very close to the standard 2SLS estimates whether we use "PC job" as the only instrument (column 1) or "PC Skills" as the only instrument (column 2). The upper panel of Fig. A4 shows the bounds of the union of confidences intervals when we use "PC job" as the instrument: the range is entirely below the 2SLS point estimate, suggesting that the 2SLS estimate is conservative. The lower panel shows similar bounds for "PC Skills"—the implications are similar.

We can therefore conclude that under plausible exogeneity results are in line, both in sign and magnitude, with standard 2SLS results.

3.1.2. Heterogeneity by age

We split our sample in two sub-groups according to the respondent's age. The two groups include individuals aged 50–64 and 65+, respectively. In Table A3, we report 2SLS estimates from the Equation (1), including both instruments (columns 1 and 4) and a single instrument, either pc-job (columns 2 and 5) or pc-skills (columns 3 and 6).

Importantly, while the main parameter estimates hold both in terms of magnitude and sign with respect to full-sample estimates, confirming our finding that online health-related information seeking strongly reduces vaccine hesitancy; the Sargan–Hansen test rejects the joint null hypothesis that the instruments are valid instruments for sample 50–64.

3.1.3. Group-IV estimator

In an alternative specification, following the approach by Dengler et al. [14] and Green et al. [21], we employ a group-IV estimator on those who ever worked, instead of the individual level-IV estimator used in the main text. We use as an instrument the group average (excluding the *i*th individual) of computer usage on the workplace among individuals of the same age band (5-year wide), employed in the same sector (1-digit ISCO) and from the same country, in order to account for differences in job computerization and digitalization rates across SHARE countries.

While the share of other workers using the computer on the workplace should exert a positive influence on the probability of individual *i*'s computer use, it is unlikely that the sector-specific share of computer users directly influences individual intentions about Covid-19 vaccine. Table A4 reports the main parameters of interest. The results confirm the findings reported in the baseline estimates.

3.1.4. Leave-one-out analysis

We perform a series of 28 leave-one-out analyses, where we routinely exclude one country at a time from the estimation sample. Figure A5 reports the main parameter estimates of Equation (1) where the dependent variable is "Hesitant". Compared to Table 1 (column 2), the results are virtually unchanged both in terms of sign and statistical significance.

4. Discussion

In this paper, we investigate the relationship between online health information seeking and vaccine hesitancy during the Covid-19

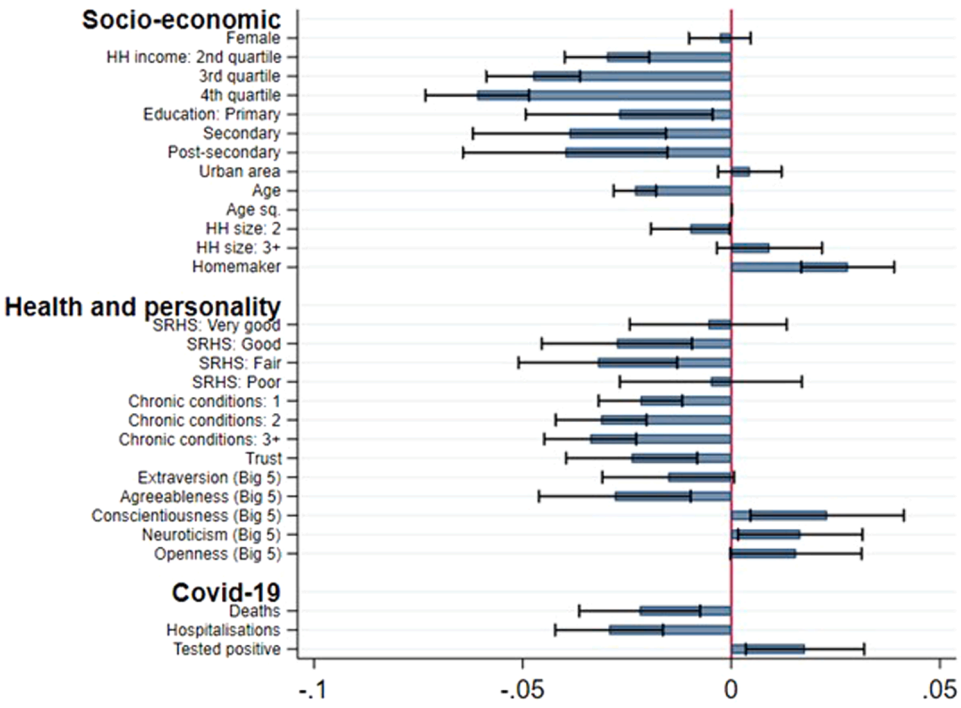

Fig. 2. Determinants of vaccine hesitancy.

Table 2
Plausible exogeneity results.

	(1) Hesitant	(2) Hesitant
2SLS	−0.116***	−0.099***
	(0.017)	(0.013)
Plausibly exogenous	−0.120***	−0.093***
	(0.012)	(0.009)
Controls	yes	yes
Country FE	yes	yes
Instrument	PC job	PC skills
Obs.	34,309	34,309

Notes: The table repots the 2SLS parameter estimates and the plausibly exogenous (LTZ) approach. Full list of covariates included. Standard errors in parentheses. ***, **, * indicate significance at 1 %, 5 % and 10 %, respectively.

pandemic. The main results show that there is a negative association between health information seeking and vaccine hesitancy. In particular, individuals who acquired their computer skills at work and look for health information online are less likely to be hesitant towards vaccination. Related to this result, it is important to note that vaccine hesitancy, in general and in the specific case of Covid-19, is often targeted by communication efforts undertaken by health institutions. The initiatives have aimed at both updating and implementing national immunization plans consistently with scientific evidence and developing tools to identify salient narratives and rhetorical styles common to anti-vaccine and COVID-denialist media [22,35]. Thus, while our findings emphasize the importance of individual capacities in interpreting online content, it is worth noting that the quality of health information published by health institutions online may still pose a challenge, particularly for individuals with lower levels of digital literacy [31].

The same is true for trust. Individuals with higher levels of trust are less likely to be hesitant. This result is consistent with what has been found by recent evidence showing a positive relationship between levels of trust and civic capital and the adherence to non-pharmaceutical interventions, such as social distancing and mask mandate [18,20]. Moreover, our findings provide additional reinforcement to the existing evidence showing that trust and conspiracy beliefs are associated with vaccine hesitancy, encompassing both general cases and specifically in the context of COVID-19 [1,15,24]. Overall, this evidence support that idea that any effort exerted by policymakers to increase public trust may have positive spill-overs effects in terms of compliance with public health interventions.

Finally, we show that vaccine hesitancy is strongly associated with socio-economic and health-related factors. This result speaks to previous evidence reporting very heterogenous results on the link between socio-economic status and the take up of other types of vaccinations [23,38]. Our data also allows us to investigate the role of individual Covid-19 experience on vaccine hesitancy: individuals whose social network was strongly affected by the pandemic, in terms of both hospitalisations and deaths, are less likely to be hesitant towards vaccines.

These results have two main implications. First, given that online information plays a crucial role for individual (health) behaviours, policymakers and social media platform should increase their efforts to deliver online information and filter out fake news and misinformation about health issues. Several strategies might be employed to achieve this goal. For example, simplifying texts can enhance understandability and actionability, while also filtering out fake news. This can lead to facilitating better comprehension for individuals seeking information about vaccines and increasing engagement and uptake of vaccination, as well as empowering individuals to make informed decisions regarding their health. Second, investing in improving individuals' technological skills might have positive spill-over effects for public health, for example by prioritizing initiatives that promote digital literacy and technological skills development. This could involve educational programs, workshops, and online resources aimed at enhancing individuals' abilities to navigate and evaluate information online. Additionally, fostering collaborations between public health agencies, technology companies, and educational institutions can facilitate the creation of user-friendly platforms and tools that provide trustworthy health-related knowledge.

Our study has strengths and limitations that provide opportunities for future research. On the positive side, we utilized individual-level data on vaccine hesitancy, enabling us to gain a more detailed understanding of this issue and identify the individual characteristics that influence people's opinions about vaccines. On the negative side, our data do not allow us to assess the quality of the online information

accessed by survey respondents. While we appropriately controlled for cross-country differences in health information provided by health institutions, through country fixed effects in our empirical analysis, we were unable to account for heterogeneity in information quality at the individual level.

5. Conclusions

This study provides insights into the dynamics of vaccine hesitancy during the COVID-19 pandemic. We've highlighted the critical roles of online health information seeking in influencing vaccination attitudes. The findings underscore the importance of delivering accurate, accessible health information online, while also emphasizing the need for enhanced digital literacy.

Moreover, our research corroborates evidence on the link between trust and vaccine hesitancy, both generally and within the context of COVID-19. Policymakers and health institutions can leverage this knowledge to foster public trust and enhance compliance with public health measures.

Ultimately, our study reinforces the significance of individual capacities, socio-economic factors, and personal pandemic experiences in shaping vaccine hesitancy These insights provide a better understanding of the issue and pave the way for targeted interventions to promote vaccination and public health during challenging times.

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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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.healthpol.2023.104942.

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