



JRC TECHNICAL REPORT

COVID-19 Vaccination

*Exploring the behavioural determinants
and interventions through a literature review*

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Abstract

Since the rollout of the COVID-19 vaccines, a large amount of research has been conducted with various population groups across different countries to study the behavioural factors that explain when and why people accept vaccination against COVID-19. This report presents a comprehensive review of the literature on the behavioural factors and policies that can impact COVID-19 vaccination acceptance and demand. Based on the assessment of evidence from nearly 200 articles, the report highlights seven behavioural factors associated with the acceptance of vaccines and five policy interventions that increase demand for vaccines. Furthermore, to identify policies that can be implemented at scale (and in different contexts), the report discusses the COVID-19 evidence in the light of findings in relation to other infectious diseases. The scaling analysis indicates that there is strong evidence for three policy instruments that are likely to increase vaccination coverage in different contexts. These instruments are (i) guaranteed conditional cash payments in exchange for vaccination, (ii) automatic vaccination appointments with the option to cancel or reschedule the appointment, and (iii) text messages reminding people that they can receive a vaccine. The report emphasises the specific conditions under which each policy instrument is effective in changing people's vaccination intentions and behaviours, thus yielding valuable lessons for policymaking targeting vaccination decisions in a post-pandemic world.

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Finally, the authors wish to extend their appreciation to the authors of the studies and reports cited in this literature review, whose work provided the foundation for the analysis. The authors' contributions to the understanding of COVID-19 vaccine acceptance and demand are greatly appreciated, and their research will undoubtedly inform future efforts to address vaccine hesitancy and promote vaccine uptake.

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Executive summary

Policy context

The COVID-19 pandemic has offered additional evidence that vaccination, despite being one of public health's greatest achievements, faces major behavioural challenges. While medical researchers delivered a vaccine within 12 months of the beginning of the pandemic, surveys that were conducted in different countries after the announcement that a vaccine might soon be available showed that nearly 30 % of the population was vaccine hesitant (Lazarus et al., 2021). Vaccine hesitancy, defined as a 'delay in acceptance or refusal of vaccination despite availability of vaccination services' (MacDonald et al., 2015), is a substantial obstacle to achieving herd immunity. During the past 2 years, a large amount of research has been conducted in different countries with various populations to investigate the behavioural and structural determinants of vaccine hesitancy. Furthermore, many policy interventions have been tested and implemented to increase vaccination uptake, targeting various determinants of vaccination-related decisions. In view of the challenges ahead, including booster campaigns or other emerging infectious threats, now is a good time to pause and look back at the body of research produced since the onset of the COVID-19 pandemic, to reflect on the lessons learnt. The insights into vaccination decisions gathered during the COVID-19 pandemic can serve to inform policies that seek to increase vaccination coverage against other types of infectious diseases in the future.

Key conclusions

This report provides a literature review of articles on COVID-19 vaccination acceptance and actual uptake¹. Based on the analysis of 196 articles, it sheds light on the behavioural determinants of vaccination-related decisions among the general adult population, parents and healthcare workers. Furthermore, the report provides insights into the design and activities of vaccination programmes to increase vaccination coverage against COVID-19. Finally, it highlights valuable lessons about how these insights can be leveraged in the context of other infectious diseases.

Main findings

In the process of summarising the behavioural factors and policies that impact the acceptance of and demand for COVID-19 vaccines, we identified seven key factors. Greater trust in the vaccine, greater trust in the healthcare system and the government, greater uptake of trustworthy information and a higher level of perceived collective responsibility are associated with increased levels of vaccination intention or uptake, whereas lower levels of complacency, more conspiracy beliefs, more structural barriers and conditional vaccine mandates are negatively related to vaccination intention or uptake.

The policy interventions that proved to have the largest impact on vaccination behaviour and for which there is good causal evidence are:

- chatbots that provide people with safety and efficacy information and debunk misinformation about COVID-19 vaccines;
- guaranteed cash payments in exchange for vaccination;
- information about high COVID-19 vaccine acceptance rates among doctors;
- automatic vaccination appointments with the option to cancel or reschedule the appointment;
- text messages reminding people that they can receive a vaccine, in particular when the message emphasises ownership (e.g. 'your vaccine' or 'claim your dose').

Furthermore, in an effort to analyse policies that can be implemented at scale (in other contexts and for groups other than those for whom the policy originally worked), this report discusses the scalability of policies that target vaccination behaviour. Specifically, it discusses evidence of whether policies that increased COVID-19 vaccination coverage can improve vaccine coverage against some other types of infectious disease. The report concludes that there is strong evidence in support of three policy instruments that are likely to impact vaccination decisions in different contexts and for different demographic groups: (i) guaranteed conditional

¹ Vaccination acceptance refers to the willingness or intention to get vaccinated, while vaccination uptake refers to the actual rate of vaccination among the eligible population. Acceptance focuses on attitudes and intentions, whereas uptake focuses on the concrete action of receiving the vaccine.

cash payments in exchange for vaccination, (ii) automatic vaccination appointments with the option to cancel or reschedule the appointment, and (iii) text messages reminding people that they can receive a vaccine. The report emphasises the specific conditions under which each of these policy instruments works well to change people's vaccination intentions and behaviours in the context of COVID-19 and other infectious diseases.

Related and future Joint Research Centre work

Moving forward, the Joint Research Centre (JRC) is committed to further investigating the behavioural and structural determinants of vaccine acceptance and demand, not only in the COVID-19 context. Specifically, the JRC is committed to analysing the data collected from surveys and experiments that have already been conducted to extract insights that can be used to inform future policy decisions and interventions. The JRC recognises that the findings of such analysis have the potential to significantly improve our understanding of the factors that drive vaccine hesitancy and uptake, and to inform the design and implementation of future vaccination campaigns. To realise this potential, the JRC will continue to engage in rigorous research activities and collaborate with relevant stakeholders in the fields of public health policy and behavioural science.

Ultimately, the JRC's work in this area will help to promote public health and protect populations against the spread of infectious diseases. Work will include examining the role of social and cultural factors in shaping vaccine-related decisions, and the impact of vaccine policies and interventions on population-level uptake.

Overall, the JRC recognises the critical importance of addressing vaccine hesitancy and promoting vaccine uptake in the fight against vaccine-preventable diseases. By continuing to conduct research and collaborate with stakeholders, the JRC is committed to advancing understanding of these issues and supporting efforts to protect public health and prevent the spread of infectious diseases.

1 Introduction

Within 12 months of the beginning of the COVID-19 pandemic, medical researchers delivered a vaccine that protects people from SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2). Thanks to this effort, COVID-19 vaccines became available in early December 2020. On 21 December 2020, the European Medicines Agency (EMA) granted, for the first time, marketing authorisation for the vaccine developed by BioNTech and Pfizer to prevent COVID-19 in people aged 16 years or above. At the time of writing, there were seven vaccines authorised for use in the EU⁽²⁾. All seven had been proven to be highly protective against hospitalisation, severe disease and death⁽³⁾. EMA had also recently approved four updated COVID-19 vaccines, which are specifically designed to provide more comprehensive and wider protection against various virus variants following the initial vaccination. Effective and broad vaccination is the best strategy to overcome the pandemic: recent evidence suggests that vaccinations may have saved between 14 million and nearly 20 million deaths in the first year of COVID-19 vaccination alone (Watson et al., 2022).

As of June 2022, more than 5 billion people had received their first dose of a COVID-19 vaccine, representing 66 % of the world population. There is a stark gap between vaccination rates in different countries: while the share of the population receiving at least one dose in high-income countries reached 70 % (e.g. 75.6 % of the population in EU/EEA countries received at least one dose of a COVID-19 vaccine⁽⁴⁾), the share of the population receiving at least one dose in many low-income countries is lower than 20 % (e.g. 10 % in Mali, 18 % in Nigeria)⁽⁵⁾. Increasing vaccine uptake rates is vital to manage the pandemic in countries with a low share of people who are fully vaccinated. Furthermore, given that COVID-19 vaccines appear to be less effective over time, vaccinated individuals are required to receive booster doses when needed. In the EU, for instance, 52.7 % of the population received a first booster and 3.2 % received a second. Thus, to overcome the pandemic, it is important to view vaccination as a repeated collective effort that needs to be sustained over time.

While governments and public institutions continuously work on the supply of COVID-19 vaccines, ensuring fair and equitable access for everyone, policymakers need to pay increasing attention to the demand side given the number of vaccine-hesitant individuals. Vaccine hesitancy, meaning delaying or refusing vaccination when the vaccine is available, is one of the most pronounced obstacles to achieving herd immunity (World Health Organization, 2014). This is no different for the ongoing COVID-19 immunisation programmes (Solís Arce et al., 2021; Temsah et al., 2021; Steinert et al., 2022). During the past 2 years, a large amount of research has been conducted in different countries with various populations to investigate vaccine acceptance and demand in different contexts and to better understand the determinants of vaccine hesitancy. Furthermore, many interventions have been tested and implemented to increase the uptake of vaccines, targeting various determinants of vaccination-related decisions. In view of the challenges ahead, including booster campaigns or other emerging infectious threats, now is a good time to pause and look back at the body of research produced since the onset of the COVID-19 pandemic, to reflect on the lessons learnt.

This report provides a literature review of recent articles on COVID-19 vaccination demand and acceptance. Based on the analysis of 196 articles, it aims to shed light on the behavioural determinants of vaccination-related decisions among the general adult population, parents and healthcare workers, and to provide insights into the design and activities of vaccination programmes to increase vaccine coverage against COVID-19 and other infectious diseases. The searching process was conducted between 1 February and 13 April 2022 in four databases (PubMed, JSTOR, EconLit, Research Papers in Economics (RePEc) / Internet Documents in Economics Access Service (IDEAS) and Scopus) and using methods such as a call for relevant literature on the Economic Science Association's methods discussion forum. The search was restricted by date of publication, from 2020 to 2022.

⁽²⁾ See EMA's website (<https://www.ema.europa.eu/en/human-regulatory/overview/public-health-threats/coronavirus-disease-covid-19/treatments-vaccines/covid-19-vaccines>).

⁽³⁾ See the EU's official statement (https://ec.europa.eu/info/live-work-travel-eu/coronavirus-response/safe-covid-19-vaccines-europeans_en).

⁽⁴⁾ See the European Centre for Disease Prevention and Control's COVID-19 vaccine tracker (<https://vaccinetracker.ecdc.europa.eu/public/extensions/COVID-19/vaccine-tracker.html#uptake-tab>).

⁽⁵⁾ See *The New York Times* vaccine tracker (<https://www.nytimes.com/interactive/2021/world/covid-vaccinations-tracker.html>). It is worth noting that the EU is leading a global cooperation and solidarity effort, COVAX, aiming to establish equitable access to COVID-19 vaccines. Team Europe has so far shared more than 400 million vaccine doses with countries around the world. See https://ec.europa.eu/info/live-work-travel-eu/coronavirus-response/safe-covid-19-vaccines-europeans/global-response-coronavirus_en#covax%20and%20https://www.gavi.org/covax-facility.

The report consists of three main sections. The next section summarises the behavioural determinants of COVID-19 vaccine acceptance and demand. From 124 studies covering 173 countries, seven key behavioural factors have been identified: trust in the vaccine; trust in the healthcare system and the government; perceived personal risk; perceived collective responsibility; media and social influence; structural barriers; and vaccine mandates. The third section focuses on interventions aiming to promote vaccine acceptance and uptake, including standard information communication, financial incentives and interventions relying on insights from behavioural sciences (e.g. framing effects, social-norm-based messages, reminders, defaults). Based on the findings of the previous two sections, the fourth section discusses the scalability of policies that were found to change vaccination decisions in the context of COVID-19, thus addressing lessons and insights for vaccination policies in a post-pandemic world. It also emphasises the major gaps and policy-relevant questions that remain unanswered.

2 Key behavioural determinants of COVID-19 vaccine acceptance and uptake

At their outset, most COVID-19 vaccination programmes focused on the supply side, ensuring the availability of vaccines for all those eligible. However, the vaccination trajectory starts to take shape before the approval and diffusion of the vaccine, when people begin to receive information on the vaccine and consider whether to get vaccinated. Vaccine decisions are usually complicated and multifactorial, resulting from personal beliefs and attitudes, social influence and institutional barriers (World Health Organization, 2014). Fully identifying and understanding the determinants of vaccine acceptance and uptake is the first, and key, step to reducing vaccine hesitancy.

This section is dedicated to summarising the behavioural determinants of acceptance and uptake of COVID-19 vaccines, providing a foundation for further discussions of interventions targeting different behavioural determinants and subsequent policy interventions aiming to change behaviour.

We reviewed 124 articles published from 1 January 2020 to 13 April 2022. Below is an overview of the articles.

- **Research methods.** There were 100 quantitative studies based on surveys, experiments and observations, 7 qualitative studies based on interviews, 4 studies with mixed methods and 13 reviews.
- **Year of publication.** 8 articles were published in 2020, 86 in 2021 and 29 in 2022.
- **Targeted population.** 73 articles focus on the general adult population, 23 on parents and 20 on healthcare workers, and 7 do not report specific information regarding the targeted population.
- **Country where the study was conducted.** A large majority of studies were conducted in Europe and the United States, followed by Asian and Middle Eastern countries, and a very small number of studies are based on data collected in Africa and Oceania. There are 21 studies that report data from multiple countries.
- **Dose of vaccine.** Only two studies focus exclusively on acceptance of and demand for boosters, while the remaining research investigates the first and second doses.

Based on findings from the 124 articles, the report highlights seven factors explaining why some people accept a COVID-19 vaccine and are willing to receive it while others refuse it: (i) trust in the vaccine, (ii) trust in the healthcare system and the government, (iii) perceived personal risk, (iv) media and social influence, (v) perceived collective responsibility, (vi) structural barriers and (vii) vaccine mandates.

The first three are the key factors explaining COVID-19 vaccine acceptance and uptake. First, trust in the safety and efficacy of the vaccine consistently predicts vaccination intentions regardless of the population (the general population, parents deciding for their children or healthcare workers). The main concerns about vaccine safety and efficacy come from the speed of vaccine development and perceptions of insufficient testing. The second determinant, trust in the healthcare system and the government, is a significant determinant in low-, middle- and high-income countries, especially among socially vulnerable and hard-to-reach populations. The third factor, perceived personal risk, is an important element in the cost-benefit analysis of vaccine uptake for the general adult population, healthcare workers and parents deciding for their children. It has been consistently found that people with lower perceived personal risk of the disease tend to be more hesitant towards vaccine uptake.

The remaining four determinants explain, to a lesser extent, COVID-19 vaccine acceptance and demand. Regarding media source, traditional media, in general, have a positive influence on attitudes towards COVID-19 vaccines. Conversely, using social media as the main source of information is associated with holding more negative attitudes towards the vaccines. Perceived collective responsibility and social influence are associated with being more likely to intend to get vaccinated, both in the general adult population and among healthcare workers. Regarding structural barriers, the convenience of getting vaccinated has been found to affect vaccination intentions in the general population. Finally, the effects of vaccine mandates depend on the targeted population's initial attitudes towards the vaccines and one's desire for freedom to get vaccinated or not. The seven identified factors are discussed in more detail below.

2.1 Trust in the vaccine

Trust in the safety and efficacy of the vaccine has been identified as a primary determinant in vaccine acceptance and uptake in studies at different stages of the pandemic across different countries, including Bangladesh (Banik et al., 2021), Croatia (De Giorgio et al., 2022), France (Ward et al., 2020), Germany (Schmelz and Bowles, 2022; Sprengholz et al., 2022), Japan (Hara et al., 2021), Kuwait (Al-Sanafi and Sallam, 2021), the Netherlands (Antwi-Berko et al., 2022), the United Kingdom (Goffe et al., 2021; Jennings et al., 2021; Kamal et al., 2021; Knight et al., 2021; Freeman et al., 2022; Sides et al., 2022) and the United States (Kricorian et al., 2022), and in some cross-national studies (Burke et al., 2021; Piltch-Loeb et al., 2021; Salali and Uysal, 2021; Solís Arce et al., 2021; Wismans et al., 2021; Davis et al., 2022; Steinert et al., 2022). Both before and after COVID-19 vaccines became available, the main concerns identified in the surveys or interviews included the speed of vaccine development and the perceived insufficient testing, leading to fear of short-term side effects and long-term consequences, and concern about the efficacy of the vaccines.

In the early stages of the pandemic, researchers and public authorities sought to better understand the factors associated with people's acceptance of COVID-19 vaccines and their eventual uptake decisions. Back in September and October 2020, Freeman et al. (2021) collected data on vaccine hesitancy from a representative sample of the adult population in the United Kingdom. Vaccine hesitancy was measured using the Oxford COVID-19 Vaccine Hesitancy Scale. 23.9 % of respondents could be classified as vaccine hesitant, expressing concerns about the vaccines' side effects, the speed of development of the COVID-19 vaccines and the vaccines' efficacy (Freeman et al., 2021). In a nationally representative sample in the United States, Kreps et al. (2021) found that concerns about vaccine safety had the largest negative effect on respondents' self-reported intention to get vaccinated, while higher perceived efficacy of the vaccines significantly increased people's likelihood of intending to get vaccinated.

Trust in the vaccine also plays a significant role in vaccine acceptance in low- and middle-income countries. Solís Arce et al. (2021) analysed COVID-19 vaccine acceptance and its determinants in a large-scale ($N = 44\,260$) cross-national survey study, covering 10 low- and middle-income countries in Asia, Africa and South America, in addition to Russia and the United States. Their descriptive analysis showed that concerns about side effects of the vaccines were the most common factor associated with vaccine hesitancy, reflecting concerns associated with the rapid development of the vaccines and insufficient communication about vaccine safety. Banik et al. (2021) found that trust in the safety and efficiency of the vaccine could also be a good predictor of willingness to pay for a vaccine in Bangladesh: participants with more confidence in the vaccine were willing to pay more to be vaccinated.

Several studies have been carried out since the vaccines became available (i.e. when there was more information concerning the development and testing of the vaccines). Trust in the safety and efficacy of the vaccines still played an important role in explaining people's attitudes and willingness to get vaccinated. A total of 11 860 vaccinated and 10 122 unvaccinated individuals from eight European countries were surveyed between April and July 2021 (Steinert et al., 2022). The results showed that vaccine hesitancy rates varied across countries, with Spain having the lowest hesitancy rate (5.5 %) and Bulgaria having the highest (50.94 %). The main factors associated with vaccine hesitancy were found to be people's concerns about the safety and efficacy of the vaccines. Furthermore, across the countries, respondents reported a greater willingness to get vaccinated with the BioNTech/Pfizer and Moderna vaccines than with the AstraZeneca vaccine (Steinert et al., 2022), suggesting the role of confidence in safety and efficacy underlying these preferences given the public announcement in April 2021 of a possible link between AstraZeneca's COVID-19 vaccine and rare cases of unusual blood clots⁽⁶⁾. Kricorian et al. (2022) surveyed a representative sample in the United States ($N = 1\,950$) in January 2021, soon after the Pfizer and Moderna vaccines received emergency use authorisation from the US Food and Drug Administration. The results showed that Americans who considered the vaccines to be unsafe not only were less likely to intend to get vaccinated but also tended to delay vaccination to see the consequences in others.

Some studies focus specifically on vaccine acceptance and uptake among healthcare workers. On the one hand, healthcare workers are among the highest risk groups for infection. On the other hand, they are reliable sources of health information, which means that their acceptance or rejection of COVID-19 vaccines not only affects themselves but can also influence the general population's uptake of COVID-19 vaccines. In the

⁽⁶⁾ See EMA's website (<https://www.ema.europa.eu/en/news/astrazenecas-covid-19-vaccine-ema-finds-possible-link-very-rare-cases-unusual-blood-clots-low-blood>).

studies targeting healthcare workers, trust in the safety and efficacy of the vaccine remains the key factor associated with their vaccination intentions (Aci et al., 2021; Agyekum et al., 2021; Aoun et al., 2021; Bolsewicz et al., 2021; Fotiadis et al., 2021; Hara et al., 2021; Parente et al., 2021; Xu et al., 2021; Chudasama et al., 2022).

Rapisarda et al. (2021) investigated what determines whether or not healthcare workers recommend COVID-19 vaccines. In a study with 459 medical doctors in a public hospital in Sicily, Italy, strong predictors of healthcare workers' willingness to recommend the vaccines were (i) vaccine confidence, (ii) internal locus of control in terms of responding to difficulties and (iii) positive emotions such as excitement and determination. Sociodemographic factors were not good predictors. Since the survey was conducted shortly after those healthcare workers had received the first dose of a vaccine, the feeling of positive or negative emotions related to the vaccines could reflect their confidence in the vaccines, which may explain why positive emotions were strongly associated with recommendation intentions (Rapisarda et al., 2021).

For another specific population, parents who are deciding about the vaccination of their children, confidence in the vaccine is undeniably the primary behavioural determinant in their decisions. For parents who engage in a cost-benefit analysis for vaccinating their children, the perceived safety and efficacy of the vaccine are the key elements. A positive relationship between their confidence in the safety and efficacy of the vaccine and the intention to have their children vaccinated has been found in Australia (Evans et al., 2021), Bangladesh (Ali et al., 2022), Canada (Hetherington et al., 2021), Israel (Shmueli, 2022), Saudi Arabia (Ennaceur and Al-Mohaithef, 2022), the United Kingdom (Bell et al., 2020) and the United States (Ruggiero et al., 2021, Szilagyi et al., 2021).

In a large-scale survey with 17 891 pregnant women and mothers from 16 countries, Skjefte et al. (2021) found that the strongest predictors of vaccine acceptance for their children included confidence in the vaccine's safety or effectiveness, perceived risk and trust in the public health agencies. Concerns around the safety and efficiency of the vaccine mainly came from the fear of severe side effects, and from concerns regarding insufficient clinical trials and the speed of the authorisation process (Shmueli, 2023). In another large-scale survey, with 6 571 participants from South-East Asian countries, several African countries and Brazil (Bono et al., 2021), parents' intentions of getting their children vaccinated against COVID-19 were measured at various hypothetical vaccine effectiveness levels: 64 %, 72.6 % and 92.9 % of respondents intended to get the vaccine at 50 %, 75 % and 95 % effectiveness levels, respectively. This shows that higher perceived vaccine efficacy increases the benefit evaluation in the cost-benefit analysis parents do for their children, facilitating uptake.

For parents deciding for their children, trust in COVID-19 vaccines is also related to their general attitudes towards vaccinating their children and to routine childhood immunisation (Temsah et al., 2021; Ellithorpe et al., 2022). However, while prior vaccine decisions were found to predict parents' attitudes towards COVID-19 vaccination, Fedele et al. (2021) were surprised to find that 73.4 % of 1 590 Italian parents of children up to 14 years old, among whom prior vaccine coverage was very high (e.g. 98 % for polio, 98 % for measles), were hesitant to have their children vaccinated against COVID-19 in November 2020. In this study, the reasons for hesitancy included concerns about the long-term safety of COVID-19 vaccines, the fear of side effects and the perceived efficacy of the vaccine. This indicates that, due to the sudden outbreak of the COVID-19 pandemic and the relatively fast development of COVID-19 vaccines, parents may have held a more critical and prudent attitude towards COVID-19 vaccines, thus explaining why prior vaccination is less predictive of COVID-19 vaccination than of other vaccines. It is also worth noting that some vaccinations are compulsory in Italy, and high coverage rates for other vaccines might be driven by enforcement rather than only confidence.

Confidence in COVID-19 vaccines could come from three main sources: attitude towards science in general, information sufficiency and trust in the source of information. We present the first two below, and the third is discussed in detail in Section 2.2.

Trust in science is probably one of the main factors associated with people's trust in the safety and efficacy of the COVID-19 vaccines. Trust in science has been found to be positively linked to trust in COVID-19 vaccines in Türkiye, the United Kingdom and the United States (Salali and Uysal, 2021; Sprengholz et al., 2022), and the more someone reports trusting science in general, the lower is the probability that they report being vaccine hesitant in France (Ward et al., 2020), New Zealand (Winter et al., 2022) and the United Kingdom (Bell et al., 2020; Denford et al., 2022).

Trust in vaccines could also be related to insufficient information. Many of the studies found that individuals who are more knowledgeable about the pandemic or the vaccines were more likely to intend to get vaccinated (Goffe et al., 2021; Nilsson et al., 2021; Robertson et al., 2021a; Crawshaw et al., 2022; Denford et al., 2022;

Kricorian et al., 2022). These results hold especially for parents who need to decide for their children (Bono et al. 2021; Brandstetter et al., 2021) and for healthcare workers (Fotiadis et al., 2021; Pataka et al., 2021; Lataifeh et al., 2022).

It is worth noting that in specific populations, such as ethnic minority groups living in developed countries, the lack of information and communication about the safety and efficacy of vaccines was found to be a serious barrier to vaccination acceptance and demand. Deal et al. (2021) focused their research on undocumented migrants, asylum seekers and refugees living in the United Kingdom. In 32 qualitative interviews conducted in January 2021, 78 % of the respondents expressed vaccine hesitancy, and the most common reasons included strong concern about side effects and the lack of accessible information in appropriate languages regarding the efficacy and safety of vaccines. Kamal et al. (2021) report that, for people from ethnic minority groups, the provision of more information about the vaccines, including information about their effectiveness, side effects and ingredients, was identified as reducing hesitancy and increasing acceptance. However, public authorities need to pay attention to the source of information. Respondents from ethnic minority groups said that they would trust the view of someone on social media more than they would trust politicians delivering information about COVID-19 vaccine safety and effectiveness. Trusted sources varied and were more likely to be individuals with whom respondents identified, such as community members or religious leaders.

These studies show that, in the context of COVID-19, the role of trust in the safety and efficacy of the vaccine in vaccination decisions is significant, regardless of the population. The general adult population, healthcare workers and parents hold concerns about the short-term and long-term consequences of the vaccines and their efficacy.

2.2 Trust in the healthcare system and the government

Since information about the COVID-19 pandemic and vaccines mainly comes from the government and health authorities, confidence in the vaccine depends not only on the information itself, but also on people's trust in the messenger (Ward et al., 2020; Grüner and Krüger, 2021; Jennings et al., 2021; Lazarus et al., 2021; Lindholt et al., 2021; Caserotti et al., 2022; Moscardino et al., 2022; Schmelz and Bowles, 2022) and the healthcare system / experts (Grüner and Krüger, 2021; Jennings et al., 2021; Caserotti et al., 2022; Schmelz and Bowles, 2022; Turhan et al., 2022).

Specifically, trust in the government seemed to be particularly important in predicting vaccination acceptance during the period of vaccine development and early in the vaccination campaigns. In a global survey with 13 426 participants from 19 countries (Brazil, Canada, China, Ecuador, France, Germany, India, Italy, Mexico, Nigeria, Poland, Russia, Singapore, South Africa, South Korea, Spain, Sweden, the United Kingdom and the United States) in June 2020, people with greater trust in the government were more likely to get vaccinated once the vaccines became available (Lazarus et al., 2021). Lindholt et al. (2021), in another large-scale cross-national survey conducted from September 2020 to February 2021 in eight high-income countries (Denmark, France, Germany, Hungary, Italy, Sweden, the United Kingdom and the United States), found that vaccine acceptance varied across countries, with Denmark having the highest acceptance rate (83 %) and France and Hungary having the lowest (47 %). Further results demonstrated that trust in the government was positively associated with COVID-19 vaccine acceptance, while believing conspiracy theories on the government hiding information about the pandemic was a strong predictor of vaccine hesitancy (Lindholt et al., 2021).

If trust in the government and health institutions is high, people are more likely to seek information from these sources and will view information provided by them as more trustworthy, which in turn could lead to more positive attitudes towards vaccines. In a survey with a nationally representative Italian sample (Caserotti et al., 2022), respondents with a more positive attitude towards governmental measures against COVID-19 and greater trust in health institutions were less likely to be hesitant towards vaccination against COVID-19. More importantly, people who more frequently consulted information diffused by health authorities expressed less vaccine hesitancy (Caserotti et al., 2022). There are similar findings in six low- and middle-income Asian and African countries (Davis et al., 2022).

Like for the general adult population, vaccination intentions of healthcare workers in low- and middle-income countries (Aci et al., 2021; Askarian et al., 2022) and high-income countries (Bolszewicz et al., 2021; Hara et al., 2021) greatly depend on their trust in government and in the information provided by health authorities. However, among parents, trust in government has not been identified as a significant factor. It is trust in the medical system and health professionals (Szilagyi et al., 2021; Ennaceur and Al-Mohaithef, 2022) that affects vaccination decisions for their children. Among 379 Saudi Arabian parents of children aged 12–18, those who

reported a high level of trust in the healthcare system were significantly more likely to intend to get their children vaccinated (69.6 %) than those who had a low level of trust in the healthcare system (51.1 %) (Ennaceur and Al-Mohaithef, 2022). Furthermore, trusting their child's paediatrician is particularly important for parents, probably because, when it comes to decisions for their children, people tend to rely more on the opinions of the professionals with whom they most often interact (Evans et al., 2021; Szilagyí et al., 2021).

The role of trust in institutions in explaining COVID-19 vaccine acceptance and demand has also been studied in the context of vaccination decisions in vulnerable populations (Balasuriya et al., 2021; Deal et al., 2021; Kamal et al., 2021; Paul et al., 2021a; Cook et al., 2022). These studies mostly relied on focus group interviews, and collaborated with communities, attempting to reach populations seldom represented in survey data. Between January and March 2021, soon after vaccines became available, Cook et al. (2022) conducted a community-based survey among 1 058 people from ethnic minorities (including Pakistanis, Bangladeshis, Indians and Caribbeans) living in Luton, one of the few towns in the United Kingdom where fewer than 50 % of residents are white British. In this study, 46.2 % of respondents expressed hesitancy regarding vaccination, whereas vaccine hesitancy was only 23.9 % in a large representative British sample in September and October 2020 (Freeman et al., 2021). It is worth noting that Cook et al. (2022) conducted their study between January and March 2021, and that vaccine hesitancy in the United Kingdom reduced between September 2020 and March 2021⁽⁷⁾, thus suggesting that the aforementioned difference in vaccine hesitancy between the ethnic minority groups and the general UK population cannot be explained by differences in when surveys were conducted. When the respondents from ethnic minorities were asked about their reasons for not getting vaccinated, the most common responses included lack of trust in the vaccine and the government (Cook et al., 2022). In another study conducted in approximately the same period, Balasuriya et al. (2021) interviewed 72 black and Latin Americans to understand vaccine acceptance in their communities. They found that trust in the healthcare system and structural barriers to accessing vaccines were frequently cited by respondents in relation to vaccine acceptance. Furthermore, the perception of pervasive mistreatment of black and Latin American communities was associated with distrust. In fact, both pervasive historical mistreatment and medical discrimination experienced since the beginning of the pandemic were positively associated with vaccine refusal, and this relationship was mediated by low levels of trust in the healthcare system's handling of the pandemic (Paul et al., 2021b). Another qualitative study conducted in the United States from July to October 2020 focused on identifying the factors underlying vaccination decisions among homeless people (Knight et al., 2022). In-depth interviews with 94 homeless-experienced adults revealed that the majority hold positive attitudes towards COVID-19 vaccines, and those who were hesitant expressed conspiracy beliefs and mistrust in the government.

The research described above emphasises the importance of building trust in the government and health authorities, which could significantly impact the acceptance and uptake of COVID-19 vaccines among targeted populations. At the same time, it should be noted that the aforementioned studies are correlational and do not provide causal evidence that increasing trust in the government or healthcare authorities can increase COVID-19 vaccination rates. Further work employing experimental methods is needed. The evidence to date suggests, however, that increasing levels of trust in public authorities (governmental and specifically in institutions providing healthcare) may be a promising policy tool to increase COVID-19 vaccine acceptance and uptake rates. Where governmental trust cannot be easily reinforced in the short term (such as among ethnic minorities who have been exposed to discriminatory acts by public officials), the provision of social support and information by trusted community messengers would be beneficial to increase vaccination coverage (Balasuriya et al., 2021; Paul et al., 2021b; Antwi-Berko et al., 2022; Knight et al., 2022). Since the opinions of socially and economically vulnerable populations are seldom represented in online surveys carried out by researchers in different countries, more insights are needed into the attitudes of ethnic minority groups. This would be indispensable in designing more inclusive vaccination policies.

2.3 Media influence

Trust in the vaccine and in its providers often depends on the specific information that one has about the vaccine's development and distribution, and about the policymaking process, which usually comes from

⁽⁷⁾ See data published by the UK Office for National Statistics (<https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/healthandwellbeing/bulletins/coronavirusandvaccinehesitancygreatbritain/17februaryto14march2021>).

various sources, including official health organisation websites, television, social media, newspapers, families or peers.

In this digital era, social media is a common information source wherever the internet is available. During the pandemic, social media has served as a major information source, as people spent more time online. Many survey-based studies found that use of social media as the primary source of information about the COVID-19 pandemic and vaccines was negatively associated with vaccine acceptance and uptake intentions (Al-Hasan et al., 2021; De Giorgio et al., 2022; Galasso et al., 2022; Mascherini and Nivakoski, 2022). Mascherini and Nivakoski (2022) surveyed a large but non-representative sample ($N = 29\,755$) of respondents from the EU-27 and found that those who spent more time on social media or for whom social media was the main source of information reported stronger COVID-19 vaccine hesitancy. Vaccine safety concerns – one of the most common reasons for being hesitant – were also found to be related to the intensity of social media usage (Al-Hasan et al., 2021). However, another study found no significant correlation between social media usage and self-reported vaccination intentions in a representative sample ($N = 1\,012$) of the US population (Viswanath et al., 2021). This is probably due to the partisan nature of American society, which makes the format of the media less important than their partisan inclination. Viswanath et al. (2021) found that Republicans or those who consumed ‘conservative’ news media expressed being less likely to intend to get vaccinated. Moreover, several studies confirmed that people holding more conservative political views tended to report greater vaccine hesitancy (Agarwal et al., 2021; Mascherini and Nivakoshi, 2022; Winter et al., 2022).

One important reason why social media usage was found to be negatively associated with COVID-19 vaccination decisions might be the influence of conspiracy theories, which have thrived during the pandemic, particularly on social media platforms. Conspiracy beliefs about the COVID-19 pandemic and vaccines surfaced at the beginning of the pandemic. For example, a popular online rumour claimed that Bill Gates, the founder of Microsoft, created the virus and intended to use vaccines to control people, while another explained that China fabricated the virus in a laboratory and used it against Western countries (Ball and Maxmen, 2020). While social media enables fast dissemination of information, it also provides a space for the quick diffusion of false information, affecting people’s perceptions and attitudes towards the pandemic and COVID-19 vaccines.

Both a conspiracy mentality and conspiracy beliefs related to COVID-19 are continuously undermining vaccination intentions (Burke et al., 2021; Lindholt et al., 2021; Salali and Uysal, 2021; Caserotti et al., 2022; Moscardino et al., 2022). Some vaccine-hesitant individuals reported believing that the coronavirus was made by humans (Jenning et al., 2021; Kricorian et al., 2022). In addition, holding conspiracy beliefs regarding the government hiding information about the pandemic was among the strongest predictors of vaccine acceptance in a cross-national survey of eight high-income countries between September 2020 and February 2021 (Lindholt et al., 2021). Specifically, acceptance of an approved COVID-19 vaccine was 8 percentage points lower among respondents who scored highest in thinking that the government is hiding information about the coronavirus and its cures than among those who did not subscribe to conspiracies. Similar results have been found in a longitudinal survey in Poland (Oleksy et al., 2022) and among people who tested positive for COVID-19 and those who counted on others getting vaccinated (Caserotti et al., 2022). Caserotti et al. (2022) found that those who counted on others getting vaccinated tended to use social media more frequently as a source of information and possessed more conspiracy beliefs.

It is notable that, while healthcare workers are assumed to have more information from trustworthy sources and to possess more knowledge related to the development of COVID-19 vaccines, several studies revealed that, just as for the general public, usage of social media or exposure to information from social media is negatively associated with healthcare workers’ intention to receive a COVID-19 vaccine (Al-Sanafi and Sallam, 2021; Elkhayat et al., 2021; Hara et al., 2021; Parente et al., 2021).

The impact of traditional media, such as the press, radio and TV, on vaccination decisions is mixed. Some studies found that usage of traditional media was associated with greater willingness to get vaccinated. A survey conducted with a nationally representative adult sample ($N = 6\,379$) in nine Organisation for Economic Co-operation and Development (OECD) countries demonstrated that frequent consumption of traditional media was positively associated with vaccination intention, while use of social media was negatively but not significantly associated with vaccination intention (Galasso, 2022). Similar results were found in a Croatian sample: those searching for COVID-19 information mainly online had a lower likelihood of being vaccinated than those getting information mainly from more traditional media sources, such as TV and radio, or from healthcare professionals (De Giorgio et al., 2022). The potential mediating factors could be income and social status; however, the researchers did not explore this possibility. Different results were found in a cross-national sample comprising 372 participants from North America, the Middle East, Europe and Asia (Al-Hasan

et al., 2021). Al-Hasan et al. (2021) found that mainstream media (e.g. TV, newspapers) and social media both negatively predict respondents' self-reported vaccination intentions. However, the small and non-representative sample size and lack of information or analysis regarding geographical and cultural characteristics limit the quality of this finding and further interpretations.

In conclusion, while having more information about COVID-19 vaccines may be beneficial in terms of increasing acceptance and demand (Loomba et al., 2021), attention should also be paid to where the information and knowledge come from. Relying on social media as the main source of information about the pandemic has been found to be associated with lower acceptance of a COVID-19 vaccine, while the use of traditional media correlates with more positive attitudes towards a COVID-19 vaccine. These results may be partially explained by differences in the content of the provided information, with social media spreading more unverifiable information and negative news about COVID-19 vaccines than more traditional media outlets. At the same time, given the methods used by the aforementioned studies, one cannot exclude the possibility that it is not social media per se that modifies people's attitudes towards the vaccines but rather social media is used as the primary source of information by people with pre-existing lower levels of intention to get vaccinated against COVID-19. Notwithstanding this possibility, the existing literature points to two main policy actions. First, it is necessary to reinforce the regulation of social media to combat misinformation, in general, and fake news about life-saving vaccines, in particular. Second, it is important to build up public trust in health authorities to increase people's use of health institutions as a major information source (Caserotti et al., 2022).

2.4 Perceived personal risk

Low perceived level of personal risk of the disease includes low perceived level of susceptibility to contraction and/or low perceived level of severity of its consequences (Betsch et al., 2018). In the studies investigating behavioural factors related to COVID-19 vaccine hesitancy, perceived personal risk has been consistently found to be one of the main predictors of vaccination intention or uptake across countries, including Bangladesh (Banik et al., 2021), Belgium (Wismans et al., 2021), France (Hacquin et al., 2020, Ward et al., 2020), Germany (Sprengholz et al., 2022), Ghana (Zhou et al., 2022), the Netherlands (Antwi-Berko et al., 2022), Portugal (Wismans et al., 2021), the United Kingdom (Goffe et al., 2021) and the United States (Burch et al., 2022; Jaffe et al., 2022), and in low- and middle-income countries such as Burkina Faso, India and Rwanda (Solís Arce et al., 2021; Davis et al., 2022).

Although vaccinated individuals are at lower risk of suffering severe consequences from COVID-19 (Britton et al., 2020), getting vaccinated is also associated with the costs of time and effort and the potential cost of suffering side effects. Therefore, when personal protection was considered the main factor in explaining vaccine acceptance (Solís Arce et al., 2021), in the individual cost-benefit analysis a high level of complacency could significantly decrease the perceived benefit of getting vaccinated, while the cost remains unchanged, leading to people being less likely to intend to get vaccinated. For example, Leonhardt et al. (2021) explored the role of perceived personal consequences of COVID-19 infection using large-scale survey data across 51 countries ($N = 218\,956$) and found that a lower perceived threat to personal health predicted lower prosocial concern, less concern about acting against the pandemic and lower levels of vaccination intention. These relationships were most pronounced in countries such as Canada, the United Kingdom and the United States, where individualistic views are more common. Furthermore, Goffe et al. (2021) and Goodwin et al. (2022) sought to analyse whether anticipated regret (the present experience of the regret that one may feel in the future) may play a role in explaining people's vaccination intentions. Their results show that having a higher level of anticipated regret is associated with being more likely to intend to get vaccinated.

In the context of COVID-19, severe cases and death mostly affect the elderly and those with comorbidities (Mills et al., 2020), which might contribute to the perceived unnecessary of getting vaccinated among young populations. Jaffe et al. (2022) surveyed 989 American college students from four universities in spring 2021 and found that perceiving getting vaccinated as unnecessary for personal protection was a common reason for not getting vaccinated. In another college student sample from Belgium, the Netherlands and Portugal, Wismans et al. (2021) discovered that complacency was a significant predictor of vaccination intention.

A negative association between perceived personal risk and vaccination intention has also been identified among healthcare workers (Bolsewicz et al., 2021; Elkhayat et al., 2021; Chudasama et al., 2022; Lataifeh et al., 2022). In particular, having previously contracted COVID-19 led to increased complacency and was among the most mentioned reasons for vaccine refusal in 341 healthcare practitioners in Egypt (Elkhayat et al.,

2021). However, those who had not contracted COVID-19 but had experience in treating COVID-19 patients were more likely to express that they intended to get vaccinated (Pataka et al., 2021; Xu et al., 2021). This suggests that perceived personal risk played a role in vaccination intentions. Compared with getting information, including numbers of cases, from the media, being directly exposed to the disease and witnessing its severity decreased one's mental distance and thus increased one's perceived need to get vaccinated.

For parents who make vaccination decisions for their children, the perceived severity of COVID-19 and their child's susceptibility to it have been put forward as important factors in explaining parents' intention to get their children vaccinated against COVID-19 (Bono et al., 2021; Skjefte et al., 2021; Ali et al., 2022; Ellithorpe et al., 2022).

2.5 Perceived collective responsibility and social influence

Since the pandemic affects everyone in society, perceived collective risk and collective responsibility, alongside perceived personal risk, play an important role in one's vaccination decision. People might consider the disease not a severe risk to themselves but still be willing to get vaccinated to protect others.

One of the main motivations to get vaccinated against COVID-19 is to protect people living in the same household (Ennaceur and Al-Mohaithef, 2022; Galasso et al., 2022). Parents of children aged 12–18 years in Saudi Arabia were willing to get their children vaccinated to protect the health of older family members, considering their children needed to go to school and contact people every day (i.e. were likely to become infected) (Ennaceur and Al-Mohaithef, 2022). Galasso et al. (2022) also found, from surveys in nine OECD countries, that adults living with their parents are more likely to get vaccinated.

Another motivation is one's prosocial beliefs, including the notion that during the pandemic one is responsible for taking action to protect others in society and the understanding that containing the virus depends on collective action. Burke et al. (2021) surveyed 4 304 people (nationally representative except for Australia) from five English-speaking countries (Australia, Canada, England, New Zealand and the United States) about their vaccination perceptions and intentions. One of the strongest predictors of vaccination intention was the perceived effectiveness of the vaccines for protecting others. Not only the perceived risk to oneself and the perceived susceptibility of and severity for others but also collectivist and altruistic beliefs were positively correlated with vaccination intention. In this study, the level of collectivism was measured by the degree of agreement with statements such as 'I think it is important to do things for "the greater good"' or 'The well-being of those outside my family is important to me.' The level of altruism was measured by responses to statements such as 'I often do things for others more than for myself.' This was not the only study that identified a positive association between belief in collective responsibility and vaccination intention. It was also found among British (Freeman et al., 2021), French (Hacquin et al., 2020), German (Sprengholz et al., 2022) and Kuwaiti (Al-Sanafi and Sallam, 2021) respondents.

Like the motivating effect of acquaintances' perceived vaccine acceptance (see below), the positive impact of prosocial beliefs was particularly pronounced in young adults, who have been less severely affected by the virus. Between July and November 2020, Swedes aged 15–19 reported low self-susceptibility to COVID-19 but a willingness to get vaccinated to protect the elderly and others at high risk (Nilsson et al., 2021). In a college student sample in Belgium, the Netherlands and Portugal, Wismans et al. (2021) discovered that collective responsibility (including perceived risk of COVID-19 to one's social circle), altruism and the need to belong were strongly associated with vaccination intention. Prosocial beliefs have also been frequently found to be a predictor of vaccination intention among healthcare workers (Aci et al., 2021; Al-Sanafi and Sallam, 2021; Askarian et al., 2022; Lataifeh et al., 2022).

The decision to engage in some type of prosocial activity, such as receiving a COVID-19 vaccine, is the result not only of one's own sense of collective responsibility but also of one's perception of others' intentions and behaviours (Bowles and Gintis, 2011). In the context of COVID-19, many studies confirmed that perceived descriptive social norms (i.e. information about what others do or intend to do) were one of the key factors associated with vaccination intention (Davis et al., 2020; Andersson et al., 2022; Davis et al., 2022; Drajzkowski and Trepanowski, 2022; Hao and Shao, 2022; Jaffe et al., 2022). For example, Cristea et al. (2021) conducted a survey with a representative sample in Romania to investigate how social norms were related to attitudes towards COVID-19 vaccines. They found that both perceptions of the attitudes of fellow citizens towards COVID-19 vaccination and the perceived attitudes of one's acquaintances were correlated with one's own vaccination attitude. What is more, the relationship between the latter and vaccine acceptance was stronger than the relationship between the former and vaccine acceptance, suggesting that people care

more about what those around them do. These results, like many others in this section, should be viewed with caution, as the method used is not experimental. Therefore, based on these studies, it is not possible to conclude that perceived social norms cause behaviour change.

The motivating effect of perceived vaccine acceptance of acquaintances on one's own vaccination intention has also been particularly present among adolescents and young adults. In 916 adolescents, Rogers et al. (2021) found that, the more they perceived their parents' and peers' attitudes towards COVID-19 vaccines as positive, the more willing they were to receive the vaccines themselves. Rogers et al. (2021) also discovered that the perceived attitudes of parents had a larger effect. In a survey of 989 young US adults (aged 18–25), Jaffe et al. (2022) found that perceived descriptive social norms were significant predictors of vaccine hesitancy after controlling for demographics and pandemic-related experiences. However, there is evidence that the effect of social norms differs across cultures. In a cross-national survey with participants from Hungary, Israel and Japan, Goodwin et al. (2022) found that subjective pressure to get vaccinated, mainly from participants' perception of the vaccine acceptance of people around them, was associated with vaccination intention in Israel and Japan but not in Hungary. Thus, social pressure does not seem to represent a universal factor influencing COVID-19 vaccine acceptance and demand.

The results of Rogers et al. (2021) suggest a specific mechanism that may explain what makes social pressure effective in some contexts. Their study shows that family and friends play a key role in how people form opinions about COVID-19 vaccines. For example, Antwi-Berko et al. (2022) found that one of the factors that their respondents put forward as likely to influence their acceptance of COVID-19 vaccines is a recommendation from family and friends. Furthermore, results from a large-scale survey conducted by Solís Arce et al. (2021) suggest that, while people in general rely on family and friends when forming an opinion about COVID-19 vaccines, women are 3 percentage points more likely than men to rely on family and friends when deciding whether to get a COVID-19 vaccine. Finally, in a web-based survey study conducted in Italy, Moscardino et al. (2022) found that vaccine-hesitant individuals were conscious of significantly less social support from friends and family than vaccine-accepting individuals were⁽⁸⁾. The authors then conjecture that impoverished social capital may affect people's ability to discern fake news and trust healthcare institutions, thus leading to their being less likely to intend to get vaccinated.

The above evidence shows that one's vaccination decision is affected by the perception of others' attitudes and behaviours, especially those of people in one's inner social circle. It is worth noting that the impact of social norms could be negative due to the rise of 'free-riding' incentives: if others get vaccinated, then one will have less incentive to get vaccinated, as a result of being exposed to less risk; one could therefore avoid the cost of getting vaccinated and simply benefit from others' uptake. However, the findings of Argote Tironi et al. (2021) point in the opposite direction. In their experiment with 7 172 unvaccinated participants from six Latin American countries, participants who had been informed that the current expected rate of national willingness to get vaccinated exceeded the expert herd immunity requirement expressed higher levels of vaccination intention than those in the no information (control) group. This result further confirms the motivating effect of positive social norms.

2.6 Structural barriers

Whether an individual receives a vaccine depends not only on the person's acceptance of and demand for it, but also on their ability to reach or be reached by the vaccine (Crawshaw et al., 2022). In the context of COVID-19, the dominant structural barriers in low- and middle-income countries are to some extent different from those in high-income countries: fewer than 50 % of respondents in Austria put forward convenience as a facilitating factor, while more than 95 % did so in Malaysia (Marzo et al., 2022).

Davis et al. (2022) surveyed 452 people from Bangladesh, the Democratic Republic of the Congo, India, Kenya, Myanmar and Tanzania in December 2020. Vaccination acceptance was around 50 %, and people who expected vaccines to be accessible expressed higher vaccination acceptance. In Nigeria in July 2021, even though healthcare workers reported high levels of motivation and intention to get vaccinated (up to 69 %), only 32 % reported that it was very easy to get a COVID-19 vaccine and 33 % reported that they had been

⁽⁸⁾ The authors used the Multidimensional Scale of Perceived Social Support to assess the respondents' perceived social support from family and friends (e.g. 'My family really tries to help me', 'I can count on my friends when things go wrong').

vaccinated with two doses (Agha et al., 2021), which indicates that the availability of the vaccines slowed down the vaccination process.

In a literature review summarising findings from 67 studies from January 2000 to September 2021 on determinants of undervaccination in migrant populations in Europe (Crawshaw et al., 2022), information and access barriers were found to obstruct vaccination uptake. In line with the findings of this review, in ethnic minority groups and among asylum seekers, immigrants and undocumented migrants living in developed countries, the access barrier has been pronounced during the COVID-19 pandemic. In 32 qualitative interviews with undocumented migrants, asylum seekers and refugees living in the United Kingdom (Deal et al., 2021), 78 % of the respondents expressed a degree of vaccine hesitancy. Among the reasons they cited, two concerned access issues: lack of accessible information about the availability and safety of COVID-19 vaccines in an appropriate language and lack of vaccination access points for migrants who were facing barriers to healthcare. Kamal et al. (2021) had similar findings. Communications issues and logistical constraints, caused by the distant location of vaccine centres, for example, were associated with low levels of vaccination intention. In another qualitative study, Balasuriya et al. (2021) interviewed 72 black and Latin Americans in March 2021 and found that difficulties in accessing vaccines were frequently cited as the reason for vaccine hesitancy.

2.7 Vaccine mandates

In countries where vaccines have been widely available, vaccine coverage increased initially but then reached a plateau (Schmelz and Bowles, 2022). Many countries have implemented vaccine mandates with the aim of overcoming vaccine hesitancy. Since there is no standard approach to mandatory vaccination programmes (Smith et al., 2021), the discussion below follows the definition of Attwell et al. (2022): 'vaccine mandates' refers to interventions imposing negative consequences on the unvaccinated.

In a cross-national survey of 1 750 unvaccinated individuals in May 2021 (Piltch-Loeb et al., 2021), freedom was revealed to be the top concern in all four countries (Canada, Italy, Sweden and the United States). The unvaccinated held the belief that 'people should be free to decide if they get vaccinated or not with no consequences for their job or personal life' (Piltch-Loeb et al., 2021, p. 4). In a review of the research published before September 2020 about parental attitudes towards mandatory vaccination, vaccine mandates were generally considered an infringement of individual rights, and therefore unacceptable, by parents (Smith et al., 2021). If vaccination decisions are in general considered a free personal choice, does mandating vaccination diminish people's intrinsic motivation to get vaccinated?

This diminishing effect was found in a three-wave representative panel survey conducted in Germany after the vaccines became widely available (Schmelz and Bowles, 2022). The results indicate that in the absence of any mandates 3.3 % of the respondents reported being against receiving a COVID-19 vaccine. The authors then asked respondents if they would be in favour of or against receiving the same vaccine if a mandate were in place: 16.5 % reported being against receiving a vaccine under this scenario. In addition, across the three waves of the survey (May 2020, October–November 2020, May 2021), opposition to voluntary vaccination (in the absence of any mandates) reduced while opposition to imposed vaccination remained unchanged.

The effect of vaccine mandates depends on initial attitudes towards vaccines. In a large UK sample, de Figueiredo et al. (2021) found that mandates make those who already intend to get vaccinated more willing to get vaccinated. However, for those who initially had doubts and concerns about getting vaccinated, the imposed scheme led to less willingness to get vaccinated. For example, the effects of vaccine passports were mostly negative in the black community and among unemployed people, groups with lower observed uptake (de Figueiredo et al., 2021). Between April 2020 and April 2021, a serial cross-sectional survey was conducted on a quota-representative German sample for age and gender to investigate attitudes towards mandating COVID-19 vaccines (Sprengholz et al., 2022). Researchers found that, both before and after the approval of the first vaccine in Germany, those who had more trust in the safety of the vaccine and a higher level of perceived collective responsibility tended to support the mandate more. In contrast, those with a lower level of perceived risk of the pandemic showed less support for the mandate and considered that it restricted their freedom, which in turn increased vaccine hesitancy. These results inform us that it is important to have a fine-grained understanding of people's preferences in order to propose different policies that address different concerns.

2.8 Summary of the determinants of COVID-19 vaccine acceptance and demand

In the process of summarising the behavioural determinants of acceptance and uptake of COVID-19 vaccines, we identified seven key factors, which are presented in Table 1 below. Greater trust in the vaccine, greater trust in the healthcare system and the government, greater uptake of trustworthy information and a higher level of perceived collective responsibility are associated with increased vaccination intention or uptake, whereas lower levels of complacency, more conspiracy beliefs, more structural barriers and conditional vaccine mandates are negatively related to vaccination intention or uptake.

It should be noted that most of the abovementioned studies measure people's intentions of getting vaccinated against COVID-19. At an individual level, since vaccination status is often not accessible to institutions and researchers, some studies measure self-reported vaccine uptake. The common existence of the intention-behaviour gap might bring into question whether a high level of reported intention translates into vaccination uptake. In the COVID-19 context, Galasso et al. (2022), in their two-wave survey study conducted in nine OECD countries, found that vaccination intention is a crucial predictor of actual vaccination behaviour. While the vaccination rate in June/July 2021 reached 83.6 % among those who had self-reported being highly likely to get vaccinated back in December 2020, the proportion was 32.6 % among those who had reported not being at all likely to get vaccinated in December 2020.

Most of the studies conducted during the pandemic relied on web-based surveys, and thus the non-probabilistic sampling approach might lead to selection bias (Hara et al., 2021). On the one hand, participants who opted to participate in the surveys might tend to be more attentive to the COVID-19 pandemic and vaccines. On the other hand, participants in online surveys may have a relatively higher socioeconomic status and a higher level of education. Therefore, caution should be taken in the interpretation of the survey results. That is also the reason why this review includes some qualitative studies, which could serve as a complement to survey studies, especially for populations such as immigrants, ethnic minorities and asylum seekers.

Table 1. Key determinants of COVID-19 vaccination acceptance and demand based on available evidence

Determinant	Details of the determinant	Population ⁽¹⁾	Countries in which determinants are identified	Number of articles identifying the determinants
Trust in the vaccine	Higher levels of confidence in the safety and efficacy of the vaccine and fewer concerns about the speed of vaccine development and sufficient testing are associated with increased vaccination intention and uptake.	1, 2, 3	HI, LMI	58
Trust in the healthcare system and the government	Greater trust in the vaccine provider and in the authorities associated with vaccination programmes is associated with increased vaccination intention.	1, 2, 3	HI, LMI	30
Media influences	The use of social media as the main source of information is negatively associated with COVID-19 vaccination intention; using traditional media as the main source predicts increased vaccination intention.	1, 2	HI, LMI	35
Perceived personal risk	Perceived low susceptibility to contracting the virus and/or perceived low severity of the consequences of contraction are associated with low levels of vaccination intention and uptake.	1, 2, 3	HI, LMI	28
Perceived collective responsibility and social influence	The more individuals feel responsible for protecting others by getting themselves vaccinated, the more likely they are to be willing to receive a vaccine. Recommendations from acquaintances and trusted healthcare workers in the community are associated with higher levels of vaccination intention.	1, 2, 3	HI, LMI	41
Availability of vaccines	Perceived greater availability of the vaccines is associated	1	LMI	10

	with higher levels of vaccination intention.			
Vaccine mandates	Vaccine mandates are positively associated with vaccination intentions for people holding favourable attitudes towards the vaccines and negatively associated with vaccination intentions for those who value freedom in vaccination decisions.	1, 3	HI	5

⁽¹⁾ 1 = general adult population; 2 = healthcare workers; 3 = parents deciding for their children.

NB: HI, high-income countries; LMI, low- and middle-income countries.

3 Behavioural interventions to increase COVID-19 vaccine acceptance and uptake

Identifying the factors that may explain why some people are in favour of the vaccines and others are opposed to them is a crucial first step in the process of exploring what solutions may work to change the attitudes and behaviours of the hesitant population without affecting the motivation of individuals with positive pre-existing intentions. Following the identification of behavioural determinants in the previous section, this section summarises the existing literature that tests various interventions aiming to increase individuals' acceptance of and demand for COVID-19 vaccines. We identified 72 articles that investigate some type of intervention(s) to increase the demand for and acceptance of COVID-19 vaccines. All of the studies were published between 1 January 2020 and 13 April 2022. Below is an overview of the studies covered in this section.

- **Research methods.** There were 61 experimental studies (53 online experiments, 2 laboratory experiments, 4 framed field experiments, 2 natural field experiments), 4 studies based on observational data and 7 reviews.
- **Year of publication.** 55 articles were published in 2021, and 17 in 2022.
- **Targeted population.** 60 studies focus on the general adult population, 2 on parents and 1 on healthcare workers, while the remaining studies do not report information about the included population.
- **Region where the study was conducted.** 23 studies were conducted in Europe (1 in Czechia, 1 in Denmark, 1 in France, 4 in Germany, 3 in Italy, 1 in the Netherlands, 2 in Poland, 2 in Sweden, 8 in the United Kingdom), 5 in the Middle East and Asia (2 in China, 1 in Israel, 1 in Japan and 1 in South Korea), 1 in Africa (Nigeria) and 31 in the United States. There are also 4 cross-cultural studies (2 in only high-income countries, 1 in only a low-/middle-income country and 1 in both).
- **Type of intervention tested.** 24 studies test the effect of standard information tools, 23 investigate the impact of interventions leveraging insights from behavioural sciences and 15 focus on the role of financial incentives to increase vaccine acceptance and uptake.

The research discussed below aimed to test the effects of various policy interventions on people's acceptance of COVID-19 vaccines and willingness to receive one. The interventions covered can be classified into three broad categories: (i) information campaigns that provide people with the necessary information to help them make informed decisions in their own interests and in the interests of others; (ii) economic incentives, either lottery-based incentives or guaranteed cash payments in exchange for a COVID-19 vaccine; and (iii) behaviourally informed strategies that rely on people's heuristics and biases. The report discusses in detail 13 strategies that belong to one of these three broad categories.

3.1 Information tools

Standard information campaigns are one of the tools most frequently used by public authorities to promote COVID-19 vaccine acceptance and uptake, since more information is supposed to help people make better decisions in their own interests and in the interests of others and is relatively low cost to provide. The studies discussed below investigate the conditions under which providing people with factual messages can change their attitudes and/or behaviour when it comes to COVID-19 vaccines.

3.1.1 Content of the message

This section first focuses on the content of the message, trying to respond to the question 'what information should be delivered?' In traditional economic theory, more information is supposed to lead to better decisions. However, since people have limited attentional and cognitive resources (Wickens, 1980; Cowan, 2012), providing more information about COVID-19 vaccines, from their development timeline and process to their delivery, might not be the best strategy. Therefore, some studies have been conducted to empirically investigate the effect of the presentation of different information on people's vaccination decisions.

3.1.1.1 Basic safety and efficacy information

As discussed in the previous section, trust in the safety and efficacy of the vaccine is one of the foremost determinants of vaccination intention and vaccine uptake. The provision of basic safety and efficacy

information has been used as a policy tool within large-scale information campaigns in many countries. Typically, these types of campaigns convey a message that the vaccines have been proven to be safe and effective in reducing the likelihood of contracting and spreading COVID-19 and that they reduce the probability of severe consequences from the virus.

There is empirical evidence showing that a message containing basic safety and efficacy information has a significantly positive impact on vaccination intentions and uptake rates (Argote Tironi et al., 2021; Davis et al., 2021; James et al., 2021). For example, Argote Tironi et al. (2021) conducted a large-scale experiment on a representative sample of 7 172 unvaccinated participants from six Latin American countries (Argentina, Brazil, Chile, Colombia, Mexico and Peru). In the control group, without any information exposure, 59 % of participants intended to receive a COVID-19 vaccine and, on average, people were willing to wait 4.3 months to receive one. Compared with the control group, the simplest message containing only basic safety and efficacy information persuaded 7.7 % more vaccine-hesitant individuals to get vaccinated and reduced the average willingness-to-wait time by 0.41 months. It is worth noting that a lower willingness-to-wait time can be interpreted as greater trust in the vaccine given that being willing to wait longer may indicate not trusting the vaccine enough to get it as soon as it is available and instead preferring to wait longer to learn more about it through various channels. Further analysis revealed that the basic message influenced acceptance by increasing perceived safety and perceived efficacy. In addition, the treatment effect did not differ among participants with different sociodemographic characteristics, and remained positive and significant across countries. These results suggest that a simple factual message can achieve its objective, and its effectiveness is valid in various contexts across Latin America.

In fact, Argote Tironi et al. (2021) also found that additional information – such as revealing (to encourage others to trust in the vaccine) that the President of the United States, Joe Biden, received a COVID-19 vaccine, or disclosing the herd immunity threshold – had no added value. Informing participants only that the currently expected national willingness rate exceeds the expert herd immunity requirement worked significantly better than the basic information about the vaccines' safety and efficacy characteristics.

On a related topic, Kachurka et al. (2021) conducted an online experiment in a representative Polish sample to test eight messages with different focuses: vaccine producer's reputation, vaccine efficiency, vaccine safety, thorough testing, social norms, scientific authority, scarcity of the vaccines and vaccine passport. Their results show that none of the informational interventions resulted in a significant decrease in vaccine hesitancy, which was up to 45 % before the interventions. In the search for an explanation of the ineffectiveness of the interventions, Kachurka et al. (2021) noticed that some interventions backfired; for example, more participants expressed concern about non-thorough testing in the condition in which thorough testing was emphasised.

Other studies focused on the effect of highlighting COVID-19 vaccine efficacy. Two studies attempted to provide information comparing the efficacy of COVID-19 vaccines, which is less well known to the public, with the efficacy of other vaccines. Davis et al. (2021) found that providing information about the safety and efficacy of COVID-19 vaccines resulted in vaccination intention levels that were higher than those in the no information condition. Furthermore, providing the same COVID-19 vaccine efficacy information and comparing the high efficacy of COVID-19 vaccines (Pfizer, 95 %; Moderna, 94 %) with the lower efficacy of influenza vaccines (either 40 % or 60 %) resulted in a further significant increase in COVID-19 vaccination intentions, without decreasing the intention of getting an influenza vaccine. However, the results from Davis et al. (2021) were not reproduced in other studies that implemented similar, albeit not identical, interventions. For example, Trueblood et al. (2022) found no significant impact of the efficacy comparison between COVID-19 vaccines and influenza vaccines on the time participants were willing to wait to receive a vaccine and the risk perception of receiving a vaccine. In their message, COVID-19 vaccines were said to be 70 % effective based on clinical trials according to the US Food and Drug Administration, while the efficacy rate of influenza vaccines was stated to have ranged 'from 19 % to 60 % since 2010' (Trueblood et al., 2022). The differences between the efficacy rates in the two studies may explain the divergent results.

Obviously, the aim of a message delivering safety and efficacy information about vaccines is to assure the public that the vaccines are associated with little harm and that the action of receiving a vaccine yields personal and collective benefits. Considering this aim, is it a good idea to mention potential side effects of vaccination, which could increase negative opinions of a vaccine? Petersen et al. (2021) investigated this question using a large and representative sample of Americans and Danes, and found that transparent communication emphasising possible side effects significantly decreased vaccine acceptance. However, it increased trust in health authorities and decreased the likelihood of holding conspiracy beliefs. This result revealed a potential trade-off between ensuring short-term vaccine coverage and promoting long-term trust

in health authorities. Since side effects are among the common concerns raised by vaccine-hesitant individuals when the vaccines are widely available, it would be reasonable to provide information about the short-term side effects even in short messages to address the public concern. Furthermore, because people holding conspiracy beliefs regarding COVID-19 commonly think that the government is hiding things from the public, talking about side effects and being totally transparent could be an effective means to instil trust in the authorities, potentially leading to a long-term increase in vaccination uptake through the use of healthcare workers as messengers.

3.1.1.2 Emphasis on collective or individual benefits

Due to the rapid development and the novelty of COVID-19 vaccines, there are relatively high levels of uncertainty regarding their long-term safety and efficacy, which could lead to a perceived high cost of receiving one (Borah et al., 2021). Therefore, in order to win the cost-benefit battle and increase vaccine coverage, it becomes important to highlight the benefits that one can get from receiving a COVID-19 vaccine.

The benefits of COVID-19 vaccination exist at different levels and in different aspects. Inoculated individuals are at lower risk of suffering severe consequences or even death from COVID-19 (Britton et al., 2020), which can be called the 'individual/private' benefit of getting vaccinated. An individual's uptake of the vaccine could also help to decrease the spread of the virus, thereby lowering the health risk for one's family members, friends and other community members, which is the benefit of vaccine uptake at societal level. Receiving a vaccine also has economic benefits, contributing to the recovery of the economy. Studies have been conducted to compare the effectiveness of emphasising individual, collective or economic benefits, with the aim of providing some insights into the choice of content of the message when it needs to be brief and salient.

Freeman et al. (2021) designed 10 messages with different focuses and tested them on a representative sample in the United Kingdom. Among the 18 474 participants, 15.6 % and 18.4 % were identified as doubtful and strongly hesitant, respectively, according to the validated Oxford COVID-19 Vaccine Hesitancy Scale. The control condition in this experiment contained the basic safety and effectiveness statement from the UK National Health Service website⁽⁹⁾. The message addressing individual benefits had the largest effect, reducing vaccine hesitancy by 1.49 percentage points compared with the control group. Other significantly effective messages included the one directly responding to safety concerns and the one providing all the types of information. It is worth mentioning that the messages focusing on the collective benefits and the seriousness of the pandemic had no significant effect.

The study by Ashworth et al. (2021) confirmed the effectiveness of emphasising the benefits of getting vaccinated and demonstrated that stressing personal benefits worked better. Ashworth et al. (2021) tested the efficiency of a message focused on vaccine safety, three messages that emphasised private, social or economic benefits, and combinations of these messages. They found that all messages significantly increased vaccination intention compared with the one in the control group (in which vaccine hesitancy was 49 %). Overall, the private benefit message had the largest effect, increasing vaccination intention to 65 % (i.e. by 16 percentage points), followed by the combination of the three messages (private, social and economic benefits) (61 %). The social benefit message, the economic benefit message and the two-message combinations induced a 9-percentage-point increase compared with the baseline. Interestingly, Ashworth et al. (2021) found that the effect of the messages varied across people with different income levels: while the low-income participants responded the most to the combination of the three messages, those with a medium income level responded only to the private benefit message. In the high-income category, the message that combined social and private benefits worked best. The authors estimated that there would be a 20-percentage-point increase in vaccination intention if the message is tailored according to income level. However, the large positive effect of emphasising vaccine benefits found in this study has seldom been replicated in other studies implementing similar interventions. This might be explained by two factors. First, Ashworth et al.'s (2021) experiment was conducted soon after the first approval of a COVID-19 vaccine and before a COVID-19 vaccine was widely available in the United States. This was a period when information was limited and people sought the amelioration of the COVID-19 situation through vaccination campaigns. Second, their study measured people's intentions of getting vaccinated against COVID-19 rather than actual vaccination behaviour.

⁽⁹⁾ The content of the message is 'The coronavirus (COVID-19) vaccines are safe and effective, and give you the best protection against coronavirus. They have been approved by the independent Medicines and Healthcare products Regulatory Agency (MHRA)'.

In contrast to the above research, Galasso et al. (2022) found that emphasising collective benefits was more effective than stressing personal benefits. Among all the studies investigating information tools, very few have implemented follow-up measures to see the long-term impact of the interventions. In addition, many studies are conducted in a single country, limiting generalisation of the results to other social and cultural contexts. These aspects make the study of Galasso et al. (2022) a particularly interesting one. Galasso et al. (2022) studied the effectiveness of four messages (protecting the self, protecting others, protecting both the self and the country, and protecting the economy) in a two-wave survey experiment on a representative sample ($N = 6\,379$) in nine OECD countries (Australia, Austria, France, Germany, Italy, New Zealand, Sweden, the United Kingdom and the United States). The two-wave design enabled the impact of the messages on both immediate vaccination intention and reported uptake over half a year to be studied. In the first phase, in December 2020, the altruistic message of protecting others, the message highlighting the protection of both the self and the country, and the message of protecting the economy were found to significantly increase vaccination intention – by 2.2, 3.0 and 3.8 percentage points, respectively – compared with the baseline where none of these messages was given. However, the message focusing on self-protection did not have a significant influence. In the second phase, in June and July 2021, similar intervention effects on self-reported vaccine uptake were confirmed. Compared with the uptake in the control group, the authors identified an increase of 2.6, 3.8 and 2.9 percentage points for those in the altruistic message group, the group receiving the message highlighting protection of the self and the country and the economic protection group, but there was no increase under the self-protection condition.

Galasso et al. (2022) discovered some cultural heterogeneity as well: while the health message that emphasised both personal and national benefits worked best in EU countries, the altruistic and economic protection messages were more effective in the United Kingdom and the United States. However, no significant effects were found in Australia and New Zealand, which might be due to mortality rates being much lower during the study period and vaccination campaigns beginning later in these two countries, resulting in a non-urgent vaccination agenda at that time.

To conclude, based on all the above research, the evidence regarding the effects of information campaigns shows that emphasising personal, social or economic benefits of vaccine uptake is a promising policy tool. In some studies, both the prosocial message, which emphasises the collective benefits of individual vaccine uptake, and the message focusing on individual benefits increased vaccination intention or uptake, in line with the findings that both personal risk and collective responsibility are key determinants of vaccine acceptance, discussed in the previous section. When it comes to which message achieves the largest effect, the results are mixed. While the effect of personal benefit messages exceeds the influence of prosocial messages in the United Kingdom and the United States, emphasising collective benefits was found to be advantageous in other countries. Regarding the effect of basic information in terms of COVID-19 vaccine safety and efficacy, the evidence is mixed. Argote Tironi et al. (2021) found that simple messages containing only basic safety and efficacy information persuaded 7.7 % more vaccine-hesitant individuals to get vaccinated, while the study by Kachurka et al. (2021) found no effect of providing such information on the participants' self-reported intention to get vaccinated. However, what is clear from Kachurka et al.'s (2021) research and Petersen et al.'s (2021) experiment is that highlighting negative aspects (e.g. side effects) leads to lower levels of vaccination intention, although this may increase trust in the healthcare authorities.

Finally, it is worth noting that most studies investigating the effect of benefits-related information measure intentions rather than actual vaccination behaviour. Given the often-observed discrepancies between what people say and what they do, it is not clear whether information campaigns emphasising vaccine safety and efficacy or individual or collective benefits could have an impact on actual vaccination decisions.

3.1.2 Format of the message (how the information is delivered)

All the studies discussed above delivered the information in a non-dynamic format. Although more convenient and easier to implement, this might not achieve the best outcomes in terms of message communication and persuasion. A few studies tried to explore other ways to deliver vaccine-related information, and most of the alternative methods were found to have a positive impact on vaccination decisions.

3.1.2.1 Chatbots

The discussion of the determinants in the previous section showed the heterogeneity in concerns that different people might have about the vaccines. However, public authorities and health institutions often deliver a uniform message about the vaccines to the public. Therefore, COVID-19 information campaigns

suffer from the inability to address most counterarguments and tailor the information provided to different subgroups or even different individuals.

Chatbots, which are also called 'conversational agents', used to conduct an online conversation via text or text to speech, can provide people with information by engaging in an argumentative dialogue with them. In the context of COVID-19, some research explored the use of chatbots in message delivery and found them to be an effective tool to persuade people to accept the COVID-19 vaccines. Researchers have identified that chatbots' interactive nature and ability to provide counterarguments against misinformation or disinformation could be effective.

Chalaguine and Hunter (2021) conducted an experiment studying the effect of a chatbot with 300 vaccine-hesitant British participants. Responses to seven concerns, such as about side effects or the fast development of the vaccines, were prepared and registered in the chatbot. A total of 240 participants were asked to freely interact with a chatbot, while 60 participants were presented with a static web page containing the same information. The results showed that 20 % of the participants in the chatbot condition changed their hesitancy levels while only 5 % of those in the static page condition did so. These results indicate that debunking messages conveyed through a chatbot can have a positive impact on vaccination intentions. The effectiveness of the chatbot tool was confirmed in a French sample. In the experiment of Altay et al. (2021), half of the participants were offered a chance to interact with a chatbot. They were exposed to the most common questions about the COVID-19 vaccines, and they were free to click on any questions and read the responses. The other half were exposed to a brief statement about how the vaccines work. Interaction with the chatbot showed a very positive impact: it generated a 37 % increase in the number of participants who held positive attitudes towards the vaccines and a 20 % decrease in the number of participants who expressed strong intentions not to receive a vaccine. Furthermore, participants in the chatbot condition showed significantly more positive attitudes towards COVID-19 vaccines and were more likely to report being willing to get vaccinated than those who read the brief statement. The chatbot has also been proven useful for parents making vaccination decisions for their children. Instead of a one-time interaction, Hong et al. (2021) offered 31 parents a chance to use the chatbot for 12 weeks while the other 32 parents received a brochure containing the same information. After 12 weeks, parents in the chatbot condition reported higher levels of vaccination intention than those in the brochure condition. However, this result should be viewed with caution given the study's sample size.

Brand and Stafford (2022) further separated the choice element and the dialogue element of chatbots to investigate the reasons for the success of chatbots. In their choice condition, participants were able to choose the questions as in Altay et al. (2021). In the control condition, the information was also presented as a dialogue but was randomly displayed, thus preventing people from choosing a specific question. Participants in both conditions showed an increase in vaccination intention, confirming the effectiveness of the chatbot. The results suggest that choosing the questions is not key to the success of the chatbot in changing people's attitudes towards COVID-19 vaccines. The authors also found that participants who spent more time with the chatbot were more likely to trust the vaccines, perceived themselves as having more knowledge about them and were more likely to report that it was important to get vaccinated.

In general, chatbots could be a cost-effective substitute for in-person consultations with a healthcare professional in providing information and persuading people to get vaccinated. Based on the studies above, there are two factors driving the success of chatbots. First, chatbots enable people's concerns about the vaccines to be directly addressed and provide detailed and on-point information. However, the debunking intention and counterargumentative information are not enough. For example, Thorpe et al. (2021) designed a detailed response to the question 'How did the development of COVID-19 vaccines happen so fast?', a common concern dragging down vaccination intention, and presented the information graphically. However, this was not effective in increasing levels of vaccination intention or decreasing the time people were willing to wait to get vaccinated. This leads to the second key factor: the dialogue. Presenting the information as a dialogue enables participants' attention to be captured more and maintains their interest. It is commonly agreed that, due to the limited cognitive ability of human beings, having the messages appear one at a time is better than presenting all the information at once.

3.1.2.2 Video and virtual reality

There is no doubt that information presented in graphics and videos is more vivid and captures more audience attention than information presented as plain text. However, there are very few studies relying on the combination of visual and audio stimuli in the context of COVID-19 vaccines.

Jensen et al. (2021) used a short video to present four messages providing information with different focuses: vaccine safety, social norm belief, vaccine efficacy and self-efficacy. They intentionally mimicked the 30-second video adverts people are used to seeing on TV or YouTube. The message was delivered by a healthcare professional. The authors estimated that, compared with participants in the control group, who saw a placebo video, all four treatment messages increased levels of immediate vaccination intention by 5.7 percentage points. More importantly, the effect was manifested in the follow-up vaccination uptake (4 months later), which was of a similar size. However, it should be noted that the experiment was conducted on the Amazon Mechanical Turk platform; thus, the sample was not representative of the American population, which could limit generalisation of the results.

In the attempts to apply media technology in the context of COVID-19, Vandeweerd et al. (2022) went even further by creating an immersive virtual reality (VR) environment to expose participants to the experience of herd immunity. They recruited 222 Danes in a park and randomised them into a VR group or a text-and-image group. In the VR group, participants played a game in which they needed to either avoid being infected as a non-infected individual or avoid infecting others as an infected individual while in a busy square. Participants in the text-and-image group were exposed to an explanation of herd immunity presented in words and graphics. Using the difference-in-differences measure, Vandeweerd et al. (2022) found that, in vaccine-hesitant participants, the VR treatment increased levels of vaccination intention by 9.3 percentage points while the text-and-image treatment led to an increase of 3.3 percentage points, and the difference was significant. Furthermore, the VR treatment promoted perceived collective responsibility more than the text-and-image treatment. Although the sampling approach is not probabilistic and the duration of exposure to the stimuli was not controlled, this attempt opened the door to the possibility of using immersive VR in health communication.

To conclude, based on the studies discussed above, the format of an information campaign may have a significant effect on the extent to which people engage in the desired behaviour. The use of chatbots is particularly appealing given that this is a low-cost technology to implement. The research on the effects of chatbots on COVID-19 vaccine acceptance and demand highlights the importance of presenting information in a dialogue style, as this is more likely to capture people's attention than standard static displays of the same information. VR is another technology that may allow people to better grasp the consequences of their actions on others and thus to engage more in socially responsible behaviour such as getting vaccinated against COVID-19. However, implementing VR at scale is less feasible given the high implementation costs. The VR technology can, nonetheless, be used to increase awareness among a specific subgroup that may be particularly reluctant to get vaccinated and whose attention may be easier to capture using new technologies (e.g. young people).

3.1.3 Source of information (who should be delivering the message?)

Studies on the determinants of vaccine acceptance and uptake show that the source of information and how much trust people have in the information source have a significant relationship with vaccine-related decisions. The experiment of Vlasceanu and Coman (2022) provides further evidence that the public's judgement of a message can be affected by manipulating the source of information. Researchers presented identical messages with different cited information sources to participants. Precisely, participants were told that information was from political leaders (President Trump / President Biden), health authorities (Dr Fauci / the US Centers for Disease Control and Prevention), a lay citizen (a Democrat or a Republican) or a large group (of Democrats, Republicans or non-partisan people). Participants were first asked to rate the accuracy of a set of statements about COVID-19 or COVID-19 vaccines, which included accurate information (e.g. the sudden loss of smell or taste is a symptom of being infected with COVID-19) and inaccurate information (e.g. the currently approved COVID-19 vaccine can make you sick with COVID-19 because it contains the live virus). After the first rating, participants were informed of the source of the statements and were asked to re-evaluate their accuracy. Compared with the control condition, under which participants rated the statements twice, regardless of their partisanship, those in the intervention group shown that information was either from a large group or from healthcare authorities had increased knowledge regarding the pandemic, which was defined by the change in accuracy beliefs regarding the statements. However, none of the interventions led to a significant change in knowledge and vaccination intentions compared with the control group. Furthermore, when examining the impact of change in accuracy beliefs on vaccination intentions, researchers found an increase in levels of vaccination intention only for Democrats when Dr Fauci was the source of their knowledge. What is more, Reddinger et al. (2022) found in an experimental study that a vaccine endorsement by Dr Fauci reduced stated intent to vaccinate among conservatives.

Diament et al. (2022) discovered that the provision of information about the vaccines' approval process from the US Food and Drug Administration improved willingness to receive a vaccine more than the endorsement of vaccines by political leaders. Furthermore, in a study targeting black and Hispanic employees in nursing homes, who had significantly lower rates of vaccination than their peers, Feifer et al. (2021) evaluated the impact of a series of 'ask a doc' sessions in which staff could demand information directly from a doctor. They discovered that the likelihood of ethnic minority participants being vaccinated increased in comparison with white employees, implying that doctors, as a source of information, were effective in delivering vaccine-related messages to various populations, including those with low general trust in authority and in the healthcare system.

The studies discussed above clearly indicate that healthcare authorities or professionals are the best source of information for achieving an increase in levels of vaccination intention. They are followed by 'others', when the information is based on the opinions of a large group. Finally, endorsement by political leaders seems to have no effect on people's attitudes and behaviours in the context of COVID-19.

3.2 Economic incentives

Using financial incentives to motivate the public to get vaccinated is controversial. From an economic standpoint, any additional incentive to get vaccinated is likely to increase vaccine demand, thereby reducing the effective price of vaccines. Prior research in economics has found that incentives work in a range of health contexts, from home-based health monitoring for diabetics (Sen et al., 2014) and warfarin adherence (Kimmel et al., 2012) to physical activity (Patel et al., 2018) and smoking cessation among pregnant women (Berlin et al., 2021). However, research in behavioural sciences has raised three major concerns about the capacity of standard financial incentives to achieve behavioural change when it comes to activities that may benefit others (i.e. prosocial behaviours). First, recent theoretical and empirical research in behavioural economics shows that incentives may not work to encourage prosocial behaviours because most prosocial activities, such as charitable giving, volunteering for medical trials, donating blood or getting immunised, rest on people's intrinsic motivation, which can be negatively affected by the introduction of extrinsic financial rewards (Titmus, 1971; Deci, 1975; Frey and Jegen, 2001). The intrinsic motivation to do the right thing may be stronger than the motivation for financial compensation, and the two motives may not comfortably coexist in the context of vaccination. The second reason why the use of financial incentives may backfire in the context of vaccination is that people may perceive the choice of receiving a vaccine as a 'sacred value'. This concern relates to a broader problem of 'commodification' and whether everything can and should be priced (Robertson et al., 2021b). The third reason why financial incentives may backfire is that a payment can signal that a vaccine is extremely risky and that a high payment is necessary in order to motivate people to receive it, which in turn may reduce the demand for it.

In the context of COVID-19, financial interventions tested in online experimental studies or evaluated in the field can be divided into two main categories: lottery-based incentives and guaranteed payments. Lottery-based incentives often involve a significant potential reward but low expected value when the probability of winning is taken into account, whereas guaranteed payments are usually smaller, such as EUR 10–50 or a cash-equivalent commodity.

According to the studies focused on COVID-19 vaccination uptake, lottery-based incentives have mainly been found to have null effects, whereas there is mixed evidence for the crowding-out effect of guaranteed rewards. Guaranteed payments, in general, have a positive effect on COVID-19 vaccine acceptance and demand. However, the effect varies according to the targeted population's ethnicity, age and trust in governmental authorities.

3.2.1 Lottery-based incentives

The state government of Ohio, United States, was the first to implement a large-scale real-life lottery intervention in the context of COVID-19. In this intervention, called Vax-a-Million, all Ohio residents were told that they would be eligible for a lottery if they had received the first dose of a COVID-19 vaccine by the date of the draw. The prize for people aged 18 or over was USD 1 million. For those aged 12–17, the prize was a full scholarship to any public college or university in Ohio. The lottery was drawn on a weekly basis from 26 May to 23 June 2021.

The evaluation of this programme yielded mixed results. Barber and West (2022) applied the difference-in-differences method and found that, relative to other comparable states, the intervention led to a 0.7-

percentage-point increase in the share of the state population receiving at least one dose of a COVID-19 vaccine during the programme. However, Lang et al. (2022), who used a synthetic control approach for better control of the natural trend of vaccination, found no evidence that the lottery had a significant effect on vaccination uptake. In fact, the authors estimated that the real effect on the vaccination rate was a 0.9-percentage-point decrease compared with the constructed counterfactual situation of what would have happened in Ohio if no intervention had been implemented, suggesting the impact of the lottery was null or even negative. According to their exploratory analysis, Ohio does not seem to be unique in this regard. No significant impact of lotteries was found in 17 other US states that announced lotteries following Ohio's Vax-a-Million.

However, it should be noted that one study (Robertson et al., 2021c) obtained different results. The authors found that the lottery programme implemented in June 2021 generated a significantly positive impact on vaccine uptake up to 30 days after the announcement in 10 out of 12 states. It should be noted that their results were based on the assumption of a 'parallel trend' between the treated counties and the untreated counties.

Given the prior mixed results, Dave et al. (2021) drew on a large amount of observational data (from 28 April to 1 July 2021) and investigated the impact of a lottery announcement in 19 US states using the same difference-in-differences method as used by Robertson et al. (2021c). They found that the announcement of a lottery did not significantly impact the vaccination rate up to 14 days after the announcement. This result was confirmed by Thirumurthy et al. (2022), who combined information on state-wide incentive programmes and data on the daily number of vaccine doses administered in each state to evaluate the financial incentives implemented from April to July 2021 in 24 states. Through the difference-in-differences analyses and the synthetic control approach, they provided evidence of the ineffectiveness of lotteries on vaccination uptake 14 days after the introduction of the incentives. These results were robust across states regardless of their political inclination (i.e. whether the state voted for the Republican or the Democratic candidate in the 2020 US presidential election).

The aforementioned studies rely on observational data. To study the effect of lottery-based incentives on COVID-19 vaccination, Taber et al. (2021) designed a laboratory experiment in which they put their 863 American participants in a fictitious scenario and manipulated the structure and the framing of the cash lottery to see whether this would influence its impact on vaccination intention. For example, they varied the lottery structure, ranging from 500 000 people winning USD 10 each to 1 person winning USD 5 million. The authors also tested whether describing the lottery with a gain frame – emphasising the positive outcome of engaging in the behaviour – or a loss frame – emphasising the negative outcome of not engaging in the behaviour – influenced vaccination intentions. They found that lotteries failed to increase levels of vaccination intention regardless of their structure or framing. Even though evidence showed that participants perceived the differences between different lotteries – for example, anticipated regret increased when the number of winners increased – behavioural reactions did not differ as a result of these differences.

According to the studies evaluating non-experimental data, lottery-based incentives failed to have a positive impact on vaccination rates. However, since all the lottery-based interventions were implemented in the United States, the conclusion here is preliminary and does not rule out the effectiveness of lottery-based incentives in other cultural contexts and in specific population subgroups. Further studies are necessary to evaluate the impact of lottery-based incentives in relation to COVID-19 vaccines and other types of vaccine.

3.2.2 Guaranteed cash payments

In contrast to lottery-based incentives, another type of financial incentive, guaranteed cash payment, has been tested in countries other than only the United States.

In Sweden, Campos-Mercade et al. (2021) found a promising effect of guaranteed small cash rewards in a large-scale experiment conducted between May and July 2021. Guaranteed payments of SEK 200 (about EUR 19) led to a 4.2-percentage-point increase in vaccination rates, from a baseline of 71.6 %, within 30 days of vaccines becoming available to the participants. Similar effects were found within 50 days. The study also included a number of nudges that proved to have no significant effect. The guaranteed financial reward was the only one that had a significant impact on actual vaccination uptake. It is worth noting that the authors argued that the failure of nudges to alter people's vaccination decisions may be explained by high levels of vaccination intentions at baseline. In other words, Swedes had a relatively high pre-existing motivation to get vaccinated, and nudges were not able to change the behaviour of the vaccine-hesitant minority.

The effectiveness of guaranteed financial payments on self-reported vaccination intention has also been tested in Germany. Back in November 2020, when a COVID-19 vaccine was not yet available, Sprengholz et al. (2021) found no effect of monetary incentives ranging from EUR 25 to EUR 200 on the vaccination intentions of Germans. In a large-scale nationally representative survey conducted in March 2021, Klüver et al. (2021) found that both hypothetical EUR 25 and EUR 50 incentives failed to persuade those who firmly refused to receive a vaccine (categorised according to their pre-treatment vaccination intentions). However, for those who were undecided, a EUR 50 incentive had a positive impact, increasing the level of vaccination intention by 5 percentage points.

These results suggest that small financial incentives in the form of guaranteed payments can encourage undecided individuals to get vaccinated but may have a more limited impact on those who strongly oppose vaccination in the first place. Sprengholz et al. (2022), for instance, found that people who were still unvaccinated in 2022 tended to have a strong defensive attitude towards the vaccines, which might not be mitigated by even high financial incentives.

Germany and Sweden had an average acceptance rate of approximately 70 % in the first half-year of 2021, similar to the average rate of most countries in western Europe but higher than in other countries, such as the United States (Galasso et al., 2022; Steinert et al., 2022). The effect of monetary incentives might be different according to the baseline intention rates. Chang et al. (2021) conducted a randomised controlled trial between 24 May 2021 and 16 July 2021 to test the impact of financial incentives on stated COVID-19 vaccination intentions in a racially and ethnically diverse population in the United States who had delayed vaccination despite weeks of eligibility and ample supply of vaccines (i.e. vaccine-hesitant individuals). Survey participants were randomised to receive no financial incentive or a financial incentive of USD 10 or USD 50 for getting vaccinated within 2 weeks of survey completion. The study's primary outcomes were whether respondents received at least one dose of a COVID-19 vaccine within 30 days of survey completion and their vaccination intentions, measured as a respondent's stated probability (0–100) of getting vaccinated in the next 30 days. The results show no significant effects of the introduction of financial incentives. In some cases, the authors found that incentives even backfired. In effect, the results show that there may be a crowding-out effect for those who are older than 40 and those who supported Trump in the 2020 election.

Baseline intentions are therefore a key element that needs to be considered when pondering the question of whether incentives can increase vaccination rates. In the United States, when applied to the general population, guaranteed cash payments have been proven effective. Serra-Garcia and Szech (2021) tested the effects of gift cards providing rewards of up to USD 500 and found that the impact of cash compensation varied according to the amount: while payments of USD 10 or USD 20 decreased levels of vaccination intention, a payment larger than USD 100 could achieve positive outcomes, and the higher the compensation, the higher the level of vaccination intention.

While some studies (e.g. Serra-Garcia and Szech, 2021) on guaranteed cash payments focus on hypothetical situations in which participants face no real consequences of their choices, Wong et al. (2022) provides some evidence based on observational data on how guaranteed rewards can impact real vaccination behaviours. The incentive programme that they studied guaranteed that a USD 25 cash card would be given to adults who either received or drove someone to receive their first dose of a COVID-19 vaccine at participating sites in four counties in North Carolina, United States. A total of 2 890 payments were given to vaccine recipients and 1 374 to drivers. The authors found that financial incentives yielded a positive result: using a difference-in-differences analysis, the actual uptake declined less at programme sites than elsewhere in the same counties and the rest of the state. However, the use of a non-randomised evaluation design makes the conclusions worth investigating with additional experimental methods.

Additional evidence from the United States showing that guaranteed payments may play a positive role comes from Duch et al. (2021), who focused on the impact of incentives on the behaviour of seeking information on how to get vaccinated, a behavioural indicator of intentions that avoids the biases associated with self-reported measures. Results show that cash payments for getting vaccinated have a significant positive effect on people's willingness to obtain information on how to get vaccinated: 16 % of individuals in the control group wanted information on where to get vaccinated, compared with 22 % in the financial compensation condition (in which participants were offered a guaranteed payment of USD 100). In contrast, being informed of a lottery jackpot of USD 1 million for vaccinated participants did not increase information-seeking behaviour.

To conclude, the research presented here shows that guaranteed cash payments are a promising policy tool to increase levels of vaccination intention and positive vaccination behaviours. However, as highlighted by the

studies discussed above, incentives work to change the behaviour of undecided individuals but fail to have an impact on individuals who oppose vaccination in the first place. In addition, the payment amount may have an impact that varies across nations or even subgroups. While small monetary incentives have been found to be effective in Europe, higher payments (more than USD 100 in most studies) were needed to produce a positive impact in the United States. Robertson et al. (2021b) discovered a non-linear trend in the response to the size of the incentive among black and Latin Americans. Specifically, a USD 1 000 or USD 1 500 reward strongly increased respondents' likelihood of intending to get vaccinated, while a USD 2 000 reward backfired, leading to a dramatic decrease in levels of vaccination intention. This suggests that there is no one-size-fits-all strategy when it comes to the use of financial incentives to promote vaccination against COVID-19. Furthermore, Robertson et al. (2021b) found that middle-income groups were most responsive to the use of financial rewards, while Republicans were less responsive than the general population to the use of financial rewards.

3.3 Interventions leveraging insights from behavioural sciences

Although traditional economic theory assumes that humans are rational beings who weigh costs and benefits when making decisions, more recent research in psychology and economics has shown that people consistently and considerably deviate from the rational model. Cognitive bias means a systematic way of thinking or behaving that leads to an outcome deviating from what a standard model based on the rationality postulate would predict (Dan, 2021). Instead of making cost and benefit calculations, people often rely on heuristics to make decisions because these facilitate the decision-making process. For example, when exposed to a lot of information, people tend to look for the information that reinforces their prior beliefs and neglect information that contradicts them (Lord et al., 1979; Nickerson, 1998; Shefrin, 1999). Also known as confirmation bias, this facilitates information processing but could lead to suboptimal choices due to the lack of knowledge of pay-off-relevant information. From a policymaking perspective, biases and heuristics can be used to design policies that target the behaviour of real people instead of individuals who exist only in theory. In effect, policies that use insights from psychology and behavioural economics are more likely to achieve the desired objectives.

3.3.1 Framing

One major insight from behavioural sciences is that people's preferences are not stable and could be affected by how particular information is presented (i.e. framing effects) (Chong and Druckman, 2007; Borah, 2011). Framing effects have been examined in fields such as psychology, politics and communication (Banks et al., 1995; Detweiler et al., 1999; Scheufele, 1999; Cox and Cox, 2001; Borah, 2011).

In the context of COVID-19 vaccine acceptance and uptake, some research sought to understand the impact of framing vaccine information in a way that emphasises benefits from vaccination (gain frame) or losses from non-vaccination (loss frame). Recent research has shown that people's information processing can be affected differently by the same information presented in a gain or loss frame.

Both gain-framed and loss-framed messages have been found to be ineffective in influencing vaccination decisions in the United States (Borah et al., 2021; Borah, 2022). For example, in Borah (2022), the gain frame described the benefits of getting a COVID-19 vaccine when available, while the loss frame highlighted the costs of not getting vaccinated. When tested on Chinese college students, the loss-frame description led to significantly higher levels of vaccination intention than the gain-frame description (Ye et al., 2021). However, another study conducted in China on a general adult sample disagreed with the previous finding: both message framings did not influence vaccination attitudes (Chen et al., 2022).

A related strand of research sought to investigate the differences between framing COVID-19 vaccine information in a positive way and framing it in a negative way. Messages with a positive framing have been found to promote vaccination intention. For example, Strickland et al. (2021) found that positive framing ('95 % of the scientific community declares the vaccine safe') increased willingness to receive the vaccines compared with the control group. A negatively framed message ('5 % of the scientific community declares the vaccine unsafe') had no effect on vaccination acceptance. The study of Barnes and Colagiuri (2022) further examined the nuances in the application of framing effects. They found that the impact depends on familiarity with the vaccine. Precisely, when the information about the side effects of vaccines was presented, a positively framed message, which emphasised that 90 in 100 people may not be affected by the side effects, was more persuasive than a negatively framed message for the least familiar vaccine (Moderna).

However, when it comes to a familiar vaccine (AstraZeneca/Pfizer), a negatively framed message, emphasising that the side effects may affect up to 1 in 10 people, was more effective than a positively framed one in increasing levels of vaccination intention. A possible explanation of the difference might lie in the interaction between trust in the vaccine and emotions related to it. Since trust has not yet been established in a less known vaccine, the negatively framed message emphasising the risk may lead to an overestimation of the small probability of experiencing side effects, and thus cause more fear. A positively framed message focusing on positive outcomes in this situation could make benefits more tangible and induce positive attitudes towards the unfamiliar vaccine. In contrast, for a known vaccine, the overestimation of small probability is mitigated thanks to the established trust.

The studies mentioned above attempted to provide some insights into the design of messages around COVID-19 vaccines by using framing effects. Loss-gain framing does not seem to be a promising tool, while a message with a positive framing of the safety and side effects of the vaccine is more persuasive than a message with a negative framing. However, people's familiarity with the vaccine plays a role in message processing. It should be noted that, given the limited empirical evidence regarding the effects of positive versus negative framing, the existing results should be viewed with caution.

3.3.2 Social norms

Since most people care to a large extent about how they are perceived by others, social norms, which can be descriptive (i.e. information about what others do) or normative (i.e. information about what behaviour others think is socially acceptable in a specific situation), play an important role in our daily decisions (Cialdini, 2003).

The previous section focusing on the main factors associated with COVID-19 vaccine acceptance and demand highlighted findings from surveys showing that information about the vaccination intentions of others and others' opinions regarding COVID-19 vaccines were good predictors of individual vaccination intentions. When studying interventions that can increase acceptance of and demand for COVID-19 vaccines, researchers focused on the impact of descriptive social norms on individual vaccination decisions without explicitly telling people what they should do. The only study testing the efficacy of normative social norms was conducted by Carey et al. (2022), with participants from Canada, the United Kingdom and the United States. Precisely, participants were informed of the percentage of their compatriots who thought that people should get a COVID-19 vaccine once they were eligible. The treatment failed to increase levels of vaccination intention in all three countries, regardless of the accuracy of the initial perceived social norm.

Although descriptive norms have been considered a promising behavioural tool in promoting health decisions (Chevallier et al., 2021), their effectiveness in the context of COVID-19 vaccines varied according to the population and the context. For the general public, studies found a null effect of social norm information on the uptake of COVID-19 vaccines (Kachurka et al., 2021; Lazić et al., 2021; Andersson et al., 2022). However, a different result was found among healthcare workers. When healthcare workers were informed that many US citizens and fellow employees had chosen to get vaccinated, the number of scheduled appointments for vaccination increased (Santos et al., 2021). Furthermore, for parents who decide for their children, the correction of misperceived social norms succeeded in decreasing conspiracy beliefs. However, this effect did not extend to vaccination intentions: no effect was detected on immediate intentions and intentions after 6 weeks (Cookson et al., 2021).

Although several correlational studies have confirmed the association between perceived social norms and COVID-19 vaccination intention among young adults (Rogers et al., 2021; Goodwin et al., 2022; Jaffe et al., 2022), social norms did not always increase levels of vaccination intention in this population'. In the United Kingdom, young people who learned that 85 % of others planned to get vaccinated reported a slightly stronger vaccination intention than those who were informed of a lower social norm, of 45 %, but the effect was not significant. In Japan, a more collectivist culture, information about peers' intentions of getting vaccinated was effective in promoting vaccination intention for the elderly but not for young people (Sasaki et al., 2022). However, it should be noted that both studies used a non-representative sample, limiting the generalisability of these results.

Because herd immunity can only be achieved through collective effort, the influence of social norms may also be dependent on a comparison of perceived uptake rates and the immunity threshold. Two studies have explored this relationship. Andersson et al. (2022) investigated the effect of herd immunity threshold communication on unvaccinated Swedish citizens. Participants were presented with either a low herd immunity threshold (60 %) or a high herd immunity threshold (90 %). No treatment effect of the threshold information was identified. More importantly, it was demonstrated that the interpretation of the immunity threshold information differed among participants: for some people, a high threshold decreased their belief

that herd immunity could be reached; for others, a high threshold made them believe that more people would get vaccinated. Similarly, a low threshold increased confidence for some people and decreased confidence for others. These two opposing impacts might be an explanation of the null effect found in the sample. In fact, these results suggest that reinforcing the social norm in the communication would be beneficial because it helps to maintain confidence regarding achieving herd immunity in the participants who could have been negatively influenced by the threshold information. However, this conjecture was not confirmed by Lazić et al. (2021). They found no effect of the additional descriptive social norm information (national vaccination coverage of 80 % or 20 %) on vaccination intentions.

In conclusion, empirical evidence shows that interventions based on social norms have a limited impact on vaccination intentions and uptake in the general public. However, the result is different for healthcare workers and parents: they were more willing to get vaccinated when they knew the acceptance and uptake rates of their colleagues or other parents. The effect found in healthcare workers and parents might be due to the important role played by the perceived closeness and similarity between the reference group and the individual (Sassenberg et al., 2011; Lee and Su, 2020). This indicates that, when implementing a social norm intervention in the COVID-19 context, it is important to pay attention to the choice of reference group. It should also be noted that research on social norms in the context of COVID-19 has focused on developed countries, and thus more exploration in other cultural contexts is required.

3.3.3 Authority effect

In the behavioural science literature, an authority effect refers to the tendency to follow the advice of authorities. In the previous section, focusing on the determinants of vaccine acceptance, we identified that people valued the opinions and recommendations of healthcare professionals in the uptake of COVID-19 vaccines. This provides a starting point for researchers to investigate whether this authority effect could be exploited to influence vaccine uptake in a positive way.

Salali and Uysal (2021) attempted to explore and compare the impact of prestige-based social influence in a cross-cultural study including participants from Türkiye, the United Kingdom and the United States. They gave participants information on the uptake of the COVID-19 vaccines by an expert scientist, the president, another political figure, a celebrity or a religious leader. They found that the most effective message was that on the uptake by an expert scientist. Instead of relying on the uptake by a single expert, Agranov et al. (2021) communicated the rate of vaccine acceptance among medical experts to a US sample of adults and detected a significant authority effect. Precisely, the uptake rate rose from 53 % to 57 % for those who were told that at least 60 % of the experts would receive the vaccine themselves; for those who were informed that 90 % of the experts planned to receive the vaccine, the uptake rate rose to 63 %.

Unlike the previous studies in which fictitious rates of vaccine acceptance among medical experts were communicated, Bartoš et al. (2022) approached the topic by eliciting the actual norm among healthcare professionals. Furthermore, they distinguished between the perceived norm (i.e. what people thought the uptake rate among healthcare professionals was) and the actual norm (i.e. the actual uptake rate among healthcare professionals). The authors conducted the first wave of data collection with 9 650 doctors in Czechia and found that 90 % intended to get vaccinated and 95 % would recommend a COVID-19 vaccine to their patients. In the second step, they recruited 2 000 Czechs and asked them what proportion of Czech doctors trust the vaccines. Then, half of the sample received information on experts' actual willingness to get vaccinated, and the other half did not. The authors found that more than 90 % of respondents initially underestimated doctors' vaccination intentions, and the most common belief was that 50 % of doctors trust the COVID-19 vaccines. When they analysed the effect of the norm-correction intervention, the authors found that the vaccination rate of those exposed to the actual norms was 4 percentage points higher than that of participants without the correction.

Do the attitudes and uptake decisions of healthcare professionals play a special role in individuals' vaccination decisions? The aforementioned evidence leads to an affirmative answer: it implies that healthcare professionals, who are considered the most trusted source of health information, could influence people's health attitudes and decisions, especially when it comes to receiving a COVID-19 vaccine, not only through direct contact and communication, but also through communication campaigns informing people about healthcare professionals' attitudes and actions.

3.3.4 Other behaviourally informed strategies

Informational interventions require a cognitive evaluation of the costs and benefits of COVID-19 vaccines. However, in the psychology literature, affective processes have also been found to play a role in different decision-making situations (Sandberg and Conner, 2008; Lerner et al., 2014; Caso et al., 2019). In the context of COVID-19, two studies have explored the impact of emotions on vaccination decisions. They emphasise the persuasive effect of messages focused on the anticipated emotional reaction. Capasso et al. (2021) randomised 484 Italian participants into four conditions: the cognitive-only condition (in which safety and efficacy information about the vaccine was provided), the cognitive plus anticipated pride in receiving the vaccine condition, the cognitive plus anticipated regret of not receiving the vaccine condition and the control condition. Results show that participants in the second condition (cognitive plus anticipated pride in receiving the vaccine) reported being more likely to intend to get vaccinated against COVID-19 than those in the control condition. The other study, by James et al. (2021), tested messages that prompted people to imagine the guilt, embarrassment and cowardice of not receiving the vaccine and spreading the disease to someone they care about. The results showed that addressing the cowardice and embarrassment affective responses significantly increased levels of vaccination intention compared with those in the control group, who received no message.

Due to the small number of studies investigating the emotional aspect of COVID-19 vaccine message content, it might be imprudent to draw any conclusion. However, it should be noted, based on the above two studies, that anticipated regret, which has often been used in behavioural change mobilisation, did not seem to work in the context of persuading people to be vaccinated against COVID-19.

While most behavioural interventions attempt to change people's minds and increase their motivation to get vaccinated, other types of strategies aim simply to decrease the likelihood of forgetting to get vaccinated, such as through the use of text reminders, or reduce the cost of getting vaccinated by making vaccination salient and easy. In a large-scale randomised controlled trial, Dai et al. (2021) sent two sequential reminders to unvaccinated participants in the United States, 1 day and 8 days after they received a notification of vaccine eligibility. The researchers discovered that receiving the first text reminder boosted appointment rates within 6 days by 6.07 percentage points (from the baseline rate of 7.20%) and vaccination rates within 4 weeks by 3.57 percentage points (from a baseline rate of 13.89%). The reminder with an ownership framing ('A COVID-19 vaccine has just been made available to you. Claim your dose today by making a vaccination appointment here...') achieved even greater impact, increasing appointment rates within 6 days and the actual uptake rate within 4 weeks by 6.83 and 4.12 percentage points, respectively. The second reminder, however, had no significant impact on vaccination uptake. These results were in line with findings from other large-scale studies targeting COVID-19 vaccine (Saccardo et al., 2021; Patel et al., 2022) and a megastudy targeting influenza vaccines during the COVID-19 period (Milkman et al., 2021). These findings highlight the intention-behaviour gap in vaccination uptake and suggest that a timely reminder is a promising intervention to get people to receive a COVID-19 vaccine.

Furthermore, it is worth emphasising the effect of leveraging psychological ownership. Dai et al. (2021) found that this was effective in increasing appointment rates. Because people value something more when it is in their possession (Kahneman et al., 1991; Beggan, 1992), and easily develop emotional attachments to what they own (Peck, 2011), emphasising that a vaccine is reserved for 'you' could help people feel entitled to a vaccine and prompt them to take action to avoid giving up what they 'own'. The effect of ownership framing has been confirmed in a German sample (Keppeler et al., 2022). The treatment group received an email about the vaccine using possessive pronouns ('your' vaccine, 'your' vaccine appointment and 'your' personal contribution). Compared with the control group, in which ownership was not emphasised, those in the treatment group were significantly more likely to click on the link to schedule an appointment to get vaccinated.

Another effective way to boost vaccine appointments is to set the default as a 'scheduled' appointment (opt-out approach) instead of asking people to book an appointment (opt-in approach) (Serra-Garcia and Szech, 2021; Tentori et al., 2021). People tend to prefer the default option that is offered to them (Samuelson and Zeckhauser, 1998). Some researchers explored the influence of different default options on uptake of vaccination against COVID-19. In a sample of 2 000 unvaccinated Italian adults aged between 50 and 59, when an appointment had been assigned to the participants (opt-out group), Tentori et al. (2021) observed an increase of 3.2 percentage points in vaccination rates compared with the opt-in group, in which participants were asked to schedule an appointment. Serra-Garcia and Szech (2021) corroborated the effectiveness of opting out being the default option. They found in an American sample that the opt-out treatment increased levels of vaccination intention by 5–6 percentage points compared with the control group. These results

indicate that a minor change in the default setting helps to prompt citizens to take the first step towards vaccination without limiting their choices.

In conclusion, the existing empirical evidence on the effects of behaviourally informed strategies highlights different tools that can be used to achieve higher levels of COVID-19 vaccine acceptance and demand. First, findings from experimental studies point to healthcare professionals, who are considered the most trusted source of health-related information, having an important role to play in influencing people's attitudes and decisions regarding COVID-19 vaccines through communication campaigns informing people about healthcare professionals' acceptance of the vaccines and their willingness to recommend them to their patients. Second, the existing research highlights two effective ways to close the gap between people's intentions of getting vaccinated and their actions: reminders and default options. It has been found that reminders work best to increase vaccination rates when the message uses possessive pronouns (e.g. 'your vaccine') and emphasises ownership (e.g. 'claim your dose'). Furthermore, repeated reminders do not appear to have a significant effect. As for the effect of default options, research suggests that automatically scheduling appointments for people to get a COVID-19 vaccine may be a promising tool to achieve higher vaccination rates. Finally, it should be noted that framing effects and social norms (not based on the attitudes or behaviour of healthcare workers) have a limited impact on the general population's willingness to receive a COVID-19 vaccine.

3.4 Summary of key interventions to increase COVID-19 vaccine acceptance and uptake

In the process of summarising the key interventions that were tested with the objective of increasing people's acceptance of and demand for COVID-19 vaccines, we identified 13 strategies, which are presented in Table 2 below. Of the 13 strategies, 5 were proven to have no or very limited impact. These are interventions that used videos or text-based messages comparing the efficacy of the COVID-19 vaccines with that of other vaccines, lottery-based incentives, messages using loss or gain frames, social-norm-based information and messages that sought to instil feelings of regret, pride or guilt. Furthermore, another three strategies had modest effects, but the existing evidence is sparse and additional research using behavioural science measures is needed to confirm whether these can be considered promising policy tools that could be used to increase rates of vaccination against COVID-19. These are messages conveying basic safety and efficacy information about the vaccine, messages that highlight collective or individual benefits and messages using positive or negative framing.

There are therefore five interventions for which there is good evidence that their implementation can significantly increase the acceptance of and/or demand for COVID-19 vaccines. The first strategy consists in the use of chatbots as a way to address people's concerns about the safety and/or efficacy of the vaccine. The chatbot tool is particularly appealing given that it is a low-cost technology to implement. The research on the effects of chatbots on COVID-19 vaccine acceptance and demand highlights the importance of presenting an information in a dialogue style, which is more likely to capture people's attention than standard static displays of the same information.

The second strategy that yielded promising results and for which there is good evidence consists in offering individuals a guaranteed payment after they get vaccinated against COVID-19. The existing evidence highlights, however, that incentives work to change the behaviour of undecided individuals but fail to have an impact on individuals who strongly oppose vaccination in the first place. Furthermore, the payment amount may have an impact that varies across nations or even subgroups.

The third strategy that led to significant increases in the uptake rates corrected people's misperceptions about doctors' trust in COVID-19 vaccines. This intervention leveraged the insight from the behavioural sciences that people are particularly influenced by the behaviour and attitudes of those who are viewed as more knowledgeable on a specific topic, for example healthcare professionals, who have been shown to be the most trusted source of information regarding vaccination. Research discussed in this section highlighted the fact that people hold incorrect beliefs about the proportion of doctors who trust COVID-19 vaccines and who are willing to recommend it to their patients. Measuring and publicly revealing the views of doctors can help to create a cheap intervention that corrects people's misperceptions and has lasting impacts on behaviour.

The fourth and fifth strategies are particularly important when people intend to get vaccinated but fail to act accordingly. To close the gap between people's intentions and their actions in the context of COVID-19 vaccination, behavioural science research suggests two empirically proven solutions: reminders and default options. Reminders work best to increase vaccination rates when the message uses possessive pronouns (e.g.

'your vaccine') and emphasises ownership (e.g. 'claim your dose'). Finally, the other solution that can significantly reduce the number of individuals who constantly delay getting a COVID-19 vaccine consists in offering automatic vaccination appointments with the option to opt out or to choose another date and time.

Table 2. Summary of tested interventions to increase COVID-19 vaccine acceptance and demand based on available evidence

Type of intervention	Intervention	Likely impact ⁽¹⁾	The intervention is especially effective when ...	Population tested	Number of studies that tested the intervention	Amount of causal evidence ⁽²⁾
Information provision (see Section 3.1)	Messages containing basic safety and efficacy information	**	People have concerns about the safety and efficacy of the vaccine	HI, LMI	5	1
Information provision (see Section 3.1)	Messages or videos that compare the efficacy of COVID-19 vaccines with that of other vaccines (should have a large contrast)	*	—	HI	2	1
Information provision (see Section 3.1)	Messages that highlight collective or individual benefits	**	People have high prosocial preferences	HI	4	1
Information provision (see Section 3.1)	Chatbots that convey debunking messages in an interactive way	***	People are misinformed or disinformed about COVID-19 vaccines and hold conspiracy beliefs related to the vaccines	HI	4	2
Economic incentives (see Section 3.2)	Lottery-based monetary incentives	*	—	HI	5	2
Economic incentives (see Section 3.2)	Guaranteed conditional cash payments	***	People lack motivation to get vaccinated because of perceived low benefit and perceived high cost	HI	6	2
Behavioural interventions (see	Messages with loss and gain framing	*	—	HI, LMI	3	1

Section 3.3)						
Behavioural interventions (see Section 3.3)	Messages with positive and negative framing	**	People have perceived low personal risk	HI	2	1
Behavioural interventions (see Section 3.3)	Social norm messages	*	—	HI	5	2
Behavioural interventions (see Section 3.3)	Messages that inform people about the uptake or attitudes of healthcare professionals	**	People consider healthcare professionals to be trustworthy, and people distrust government	HI, LMI	3	2
Behavioural interventions (see Section 3.3)	Messages that instil regret, pride or guilt	*	People have perceived low risk from the disease and perceived low benefit of getting vaccinated	HI	2	1
Behavioural interventions (see Section 3.3)	Default appointments	**	People intend to get vaccinated	HI	3	2
Behavioural interventions (see Section 3.3)	Timely reminders	**	People intend to get vaccinated	HI	3	2

(¹) * = little or no impact; ** = modest impact; *** = substantial impact. Precisely, *** denotes where an intervention causes an increase in the outcome variable (usually vaccination intention) of more than 8 percentage points, ** denotes an increase of 2–8 percentage points and * denotes no increase or an increase of 1 percentage point.

(²) 0 = no evidence; 1 = some evidence; 2 = substantial evidence. Conclusions about evidence are based on consensus among the authors of this report who considered the available evidence, including the number of available studies, evidence of a causal association, the quality of the studies and the size of the effect.

NB: HI, high-income countries; LMI, low- and middle-income countries.

4 Lessons for a post-pandemic world

This report reviewed the main factors associated with COVID-19 vaccine acceptance and hesitancy, and summarised the empirical evidence on policies to increase vaccination acceptance and demand. The large body of research discussed in the report provides new empirical evidence on strategies that may be implemented by policymakers to increase vaccination against COVID-19 and against other infectious diseases, thereby complementing the existing policy-oriented reviews on how to change health-related behaviours, in general, and vaccination, in particular (e.g. Brewer et al., 2017; World Health Organization, 2020; Chevallier et al., 2021; Galanis et al., 2021a, 2021b, 2022; Volpp et al., 2021). However, extending the lessons learnt from the COVID-19 literature to vaccination decisions in the context of other infectious diseases may be problematic for several reasons. For example, the political polarisation around COVID-19 has been found to play a role in how people respond to specific policy instruments. Chang et al. (2021) and Robertson et al. (2021b) provided evidence from the United States suggesting that Republicans are less responsive to the use of guaranteed financial rewards than Democrats. Thus, in the context of other infectious diseases, guaranteed cash payments may have a larger effect on vaccination decisions than the impact found in the COVID-19 literature because there may be less disparity in how people with different political affiliations respond to incentives to get vaccinated (e.g. incentives to get vaccinated against influenza or chickenpox). Similarly, while interventions based on political endorsement of COVID-19 vaccines were generally found to have null or even sometimes negative effects on people's willingness to receive a COVID-19 vaccine (e.g. Reddinger et al., 2022), such campaigns may prove more effective in the context of other infectious diseases, characterised by a lower level of political polarisation. Among the other reasons why the generalisation of findings from the COVID-19 literature to a post-COVID-19 world may be perilous are the limited evidence gathered during the pandemic in the case of some studies, leading to false positives (i.e. when we interpret a piece of evidence as proof that something is true when in fact it is not); the non-representativeness of the subsets of people for whom behaviour change interventions originally worked; and the idiosyncratic nature of the situation.

This section will discuss the five interventions that appear to be most promising in increasing rates of vaccination against COVID-19, pointing out whether the same or similar interventions have been found to affect vaccination behaviour in the context of other infectious diseases. Interventions for which there is strong evidence of effectiveness in encouraging people to get vaccinated in various contexts are more likely to be scalable in the future. In effect, combining evidence from the pre-COVID-19 literature with findings based on research dealing with the COVID-19 pandemic may address, to some extent, the aforementioned limits to scalability: the idiosyncrasy of the situation, the representativeness of the population and the risk of false positives.

4.1 Using chatbots to provide safety and efficacy information and convey debunking messages

The use of chatbots to address people's safety and efficacy concerns regarding COVID-19 vaccines has been found to positively impact people's attitudes towards the vaccines and their vaccination intentions (e.g. Altay et al., 2021). There appears to be no evidence on the effect of using chatbots to increase people's acceptance of and willingness to receive vaccines other than those against COVID-19. Given the number of studies that sought to identify the effects of using chatbots to change people's attitudes and vaccination intentions against COVID-19 (four studies in total), their focus on self-reported declarations of vaccination intention and the limited representativeness of the studied population (evidence exclusively from high-income countries), it is difficult to say whether this type of intervention could have similar positive results in other contexts and for other populations. Further research is needed to confirm the potential of chatbots to improve vaccination coverage in different contexts.

4.2 Offering guaranteed conditional cash payments under specific circumstances

The literature reviewed in this report studied two types of financial incentives: guaranteed financial payments and lottery-based incentives. There is strong evidence based on observations of actual uptake and

hypothetical scenarios that guaranteed payments are an effective strategy to increase COVID-19 vaccination rates among undecided individuals. The pre-COVID-19 literature investigating the effect of financial incentives reached similar conclusions. For example, Banerjee et al. (2010) found that small financial incentives have large positive impacts on childhood immunisation rates in poor areas, and Bronchetti et al. (2015) found that a financial intervention increased take-up of influenza vaccines among adults. However, the pre-COVID-19 literature provides only limited evidence on the heterogeneity of the effects. Specifically, it does not clearly indicate how the effects vary with the size of the incentive and depending on whether the incentive is fixed or variable, and how different subgroups react to the incentive. The COVID-19 literature offers a good understanding of these heterogeneity effects. Dave et al. (2021) have shown that whether the incentive is fixed or variable matters: the use of lottery-based incentives to encourage vaccination against COVID-19 has no significant effects. The magnitude of the incentive also appears to be an important factor: Robertson et al. (2021b) discovered a non-linear trend in the response to the size of the incentive among black and Latin Americans. Specifically, a USD 1 000 or USD 1 500 reward strongly increased respondents' levels of intention to get vaccinated, while a USD 2 000 reward backfired, leading to a dramatic decrease in levels of vaccination intention. Serra-Garcia and Szech's (2021) experiment provides further evidence that the magnitude of the incentive matters: they found that low payments, of USD 10 or USD 20, reduce levels of vaccination intention and that only payments of at least USD 100 significantly increase levels of vaccination intention. Finally, regarding the response of subgroups to financial incentives, Chang et al. (2021) found that financial rewards led to lower vaccination rates among US supporters of Trump in the 2020 election and appear to have similar crowding-out effects on people over 40 years old. Thus, there is strong evidence from the laboratory and from the field about the conditions under which guaranteed cash payments increase vaccination. When designed according to insights from the aforementioned literature, guaranteed cash payments are likely to lead to similar positive results.

4.3 Informing people about the vaccine acceptance of healthcare professionals

The literature that sought to investigate the causal effect of social influences on COVID-19 vaccination points out that people are influenced by the attitudes of healthcare professionals. For example, Bartoš et al. (2022) investigated trust in COVID-19 vaccines held by 9 650 doctors in Czechia and found that 90 % trusted the vaccines. The authors then randomly provided information about doctors' views to a nationally representative sample and measured its impact over 9 months. They found that individuals who received the information were 4 percentage points more likely to be vaccinated 9 months after the intervention than participants in the control group. However, informing people about the general public's acceptance of COVID-19 vaccines appeared to have no impact (e.g. Kachurka et al., 2021). To change the vaccination behaviours of the general population, it is therefore important to communicate the acceptance rate of doctors rather than that of the general public. Furthermore, social norms have the potential to change the vaccination decisions of healthcare workers and parents deciding for their children. In the context of vaccination against COVID-19, Santos et al. (2021) found that more healthcare workers registered for COVID-19 vaccination when they received information about their peers' attitudes towards COVID-19 vaccination compared with participants in the control group, who did not receive such information, and Cookson et al.'s (2021) findings showed that parents who received information about the beliefs of other parents about COVID-19 vaccines were less likely to hold conspiracy beliefs than those in the control group. The literature studying the causal effect of social norms on the acceptance and willingness to receive vaccines other than those against COVID-19 focused more on descriptive norms, and specifically the uptake rate in the general population, rather than communicating others' attitudes (Milkman et al., 2021; Galizzi et al., 2022). It is therefore unclear to what extent information about the attitudes of doctors can increase vaccination rates for vaccines other than those against COVID-19. There is also no causal evidence on how healthcare workers and parents react to information about their peers' acceptance of a vaccine other than vaccines against COVID-19. Given the limited number of studies that investigated the causal effect of informing people about the vaccine acceptance of doctors (only one study looked at actual uptake), it is difficult to say whether such an intervention would yield similar results in the case of vaccination against some other infectious disease and when implemented in a different population.

4.4 Offering people automatic appointments to get vaccinated at a given date and time with the option to opt out

Automatically scheduling appointments to get vaccinated has been shown to increase rates of vaccination against COVID-19 by making people feel committed to being vaccinated at a given date and time. For example, in a sample of 2 000 unvaccinated Italians, Tentori et al. (2021) found significantly higher vaccination rates in the treatment condition, in which people received an automatically scheduled appointment, than in the control group, in which people were asked to schedule an appointment. Similarly, in an online experiment conducted in the United States, Serra-Garcia and Szech (2021) found results that confirm the positive effect of automatically scheduled appointments with the option to opt out. Furthermore, there is strong evidence from contexts other than the COVID-19 pandemic that automatically scheduled appointments can increase vaccination rates. In a field experiment, Chapman et al. (2016) investigated the effect of such an intervention on the rate of vaccination against seasonal influenza. The authors implemented two conditions: an opt-in condition and an opt-out condition. In the opt-in condition, patients of a clinic received a letter about the availability of seasonal influenza vaccination and were informed that they could schedule an appointment to get it. In the opt-out condition, patients received a similar letter that provided a prescheduled vaccination appointment at the clinic, with an option to change or cancel the appointment. Chapman et al. (2016) found that people in the opt-out condition were significantly more likely to be vaccinated than those in the opt-in condition. In a previous study conducted with university employees, Chapman et al. (2010) had found similar results. We can therefore conclude that there is strong evidence that offering people automatic appointments to get vaccinated is a strategy that will probably have similar positive results in other contexts. It is worth noting that the current literature offers valuable insights into the population that is more likely to positively react to such default options. Serra-Garcia and Szech (2021) found that defaults more strongly affect vaccination intentions in individuals who trust the vaccines less and whose political views were less supportive of Dr Fauci's and more supportive of Trump's approach to the pandemic. Thus, there is evidence that automatically scheduling vaccination appointments may increase vaccination rates.

4.5 Sending messages to remind people that they can receive a vaccine

People often intend to get vaccinated but procrastinate by indefinitely postponing getting a COVID-19 vaccine. Reminders may close the gap between people's intentions and their actual behaviour. Several field experiments found that text reminders significantly boosted appointment rates to get vaccinated against COVID-19. The research on COVID-19 adds valuable insights into how and when reminders are most effective. First, Dai et al. (2021) found that reminders were particularly effective when sent 1 day after participants received a notification of vaccine eligibility; the second wave of reminders, sent 8 days after the initial notification, had no significant effect on the number of scheduled appointments. Second, regarding the content of the message, Dai et al. (2021) and Keppeler et al. (2022) found that reminders with an ownership framing were more powerful (e.g. 'a COVID-19 vaccine has just been made available to you. Claim your dose by making a vaccination appointment here ...'). Reminders have been shown to work well to change vaccination behaviours in contexts other than the COVID-19 pandemic. Several pre-COVID-19 studies have shown that reminders increase vaccination coverage (e.g. Jacobson Vann et al., 2018). Furthermore, Jacobson Vann et al. (2018) note that reminders are likely to be more effective when people can easily take specific actions to realise their intention to get a COVID-19 vaccine (e.g. when people can easily schedule an appointment when they receive the reminder). In a literature review, Kempe et al. (2021) argue that another aspect that can affect how reminders impact vaccination behaviour is the sender's identity. For example, reminders work particularly well when a formal authority sends the message and includes an endorsement by the patient's practice. There is therefore evidence to conclude that reminders are a scalable policy intervention to increase vaccination rates in different contexts. However, more evidence is needed on the impact of reminders on various subgroups.

4.6 Policy recommendations

Based on the causal evidence reviewed in the previous section and the scalability analysis discussed in this section, the main policy recommendations to increase vaccination behaviour in the case of an outbreak of an infectious disease can be formulated as follows.

- To increase vaccination rates among individuals who trust the vaccines less and are less likely to intend to get vaccinated, policymakers can use automatic vaccination appointments with an opt-out option. There is strong evidence from research on COVID-19 and from behavioural studies that focused on other infectious diseases that automatic vaccination appointments with the possibility of opting out are likely to achieve health-related behaviour change across contexts. There are two additional policies that have been found to be effective in the context of COVID-19 vaccination but there is less evidence on their impact on vaccination decisions in other contexts: (i) use of chatbots that provide safety and efficacy information about the vaccine and convey debunking messages, and (ii) provision of information about the acceptance of the vaccines by doctors.
- To close the gap between people's vaccination intentions and their actual uptake of the vaccines, policymakers can use the following set of instruments: (i) guaranteed conditional cash payments in exchange for vaccination, (ii) automatic vaccination appointments with the option to cancel or reschedule the appointment, and (iii) text messages reminding people that they can receive a vaccine. There is good evidence from different contexts that these policy strategies work well to achieve higher vaccination coverage.

5 Conclusions

The pandemic has offered additional evidence that vaccination faces persistent challenges despite being one of public health's greatest achievements. During the past 2 years, a large amount of research has been conducted in different countries with various populations to study the factors that influence the acceptability of COVID-19 vaccines. The research on the determinants of vaccine acceptability has been accompanied by a burgeoning literature that seeks to understand the effects of policy interventions on people's attitudes towards the vaccines, their intentions of getting vaccinated and actual uptake rates. In view of the challenges ahead, including booster campaigns or other emerging infectious threats, this report paused and looked back at the body of research produced since the onset of the COVID-19 pandemic to reflect on the lessons learnt from the literature studying the behavioural determinants of vaccine acceptability, and from research that sought to identify the causal effects of policy instruments to improve vaccine acceptance and coverage. Based on the analysis of about 200 articles published in the last 2 years, this literature review sheds light on the behavioural determinants of vaccination-related decisions of parents, healthcare workers and other adults, and provides valuable insights into the design of vaccination programmes to increase vaccine coverage.

Regarding the behavioural determinants of acceptance and uptake of COVID-19 vaccines, this report identified seven key factors, presented in Table 1. Greater trust in the vaccine, greater trust in the healthcare system and the government, greater uptake of trustworthy information and a higher level of perceived collective responsibility are associated with increased levels of vaccination intention or uptake, whereas lower levels of complacency, more conspiracy beliefs, more structural barriers and conditional vaccine mandates are negatively related to vaccination intention or uptake.

The determinants identified in this literature review relate to some of the policy interventions to encourage people to receive one of the COVID-19 vaccines. For example, researchers sought to improve vaccine coverage by increasing people's trust in the vaccines and in the vaccine providers. One of the policy lessons highlighted in this report is that information campaigns emphasising the potential side effects of the vaccines can increase people's trust in the vaccine provider but are unlikely to improve vaccination coverage. An alternative strategy that has been shown to achieve both greater trust in the vaccine provider and higher levels of vaccination intention is the use of chatbots to provide people with information about the safety and efficacy of the vaccine (thus emphasising not only the vaccine's negative side effects but also its benefits). Importantly, there is good evidence that the same safety and efficacy information presented in a more standard and static manner, compared with the dialogue style of chatbot communication, is less effective in changing people's vaccination intentions. Finally, studies that sought to emphasise the collective benefits of vaccination against COVID-19 or that implemented strategies to address complacency barriers found modest increases in levels of self-reported vaccination intention. There is less evidence regarding the causal effects of structural barriers and vaccine mandates, although one survey experiment suggests that mandates may reduce the intrinsic motivation to get vaccinated in contexts with high baseline levels of intention.

The policy interventions that proved to have the largest impact on vaccination behaviour and for which there is good causal evidence are (i) chatbots that provide people with safety and efficacy information and convey debunking messages about COVID-19 vaccines, (ii) guaranteed cash payments in exchange for vaccination, (iii) information about high acceptance rates of COVID-19 vaccines among doctors, (iv) automatic vaccination appointments with the option to cancel or reschedule the appointment, and (v) text messages reminding people that they can receive a COVID-19 vaccine, in particular when the message emphasises ownership (e.g. 'your vaccine' or 'claim your dose'). Furthermore, in an effort to analyse policies that can be implemented at scale (in other contexts and for groups other than those for which the policy originally worked), we combined evidence from the pre-COVID-19 literature with findings based on research dealing with the pandemic to see whether there is evidence that what works to combat COVID-19 could be effective in improving vaccine coverage against some other type of infectious disease. This allows us to conclude that there is good evidence that three policy instruments can effectively encourage vaccination across contexts and across demographic groups: (i) guaranteed conditional cash payments in exchange for vaccination, (ii) automatic vaccination appointments with the option to cancel or reschedule the appointment, and (iii) text messages reminding people that they can receive a vaccine. The report emphasised the specific conditions under which each of these policy instruments works well to change people's vaccination intentions and behaviours.

In addition to showing which policy instruments can be used to improve vaccination coverage across demographic groups and contexts, this literature review highlighted avenues for future research. First, there is mixed evidence from the behavioural sciences literature on messages emphasising the (collective or personal)

benefits of vaccination or on the use of social norms to increase vaccination rates. The high level of heterogeneity in the methods employed meant that we could not infer clear policy lessons from this literature. Furthermore, the existing evidence relies on self-reported measures of people's willingness to receive a COVID-19 vaccine. The lack of evidence based on actual vaccination behaviour is also a problem in the case of studies that analysed the effect of chatbots that provide safety and efficacy information and convey debunking messages, a promising policy tool. Second, the design of vaccination programmes would benefit from a better understanding of the scalability of some policy instruments, such as the communication of information about the acceptance of a vaccine by doctors. In addition, it is not clear whether information about doctors' attitudes towards COVID-19 vaccines or about their uptake works best to increase vaccination coverage.

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Abbreviations

EMA	European Medicines Agency
JRC	Joint Research Centre
OECD	Organisation for Economic Co-operation and Development
VR	virtual reality

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