Quantifying health care workers' preferences around COVID-19 vaccination: a single-profile DCE study in France

Carolina Díaz Luévano
Master of Public Health, Epidemiology
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Practicum location:
GERES
Paris, France

Professional/Academic Advisor:
Judith Mueller, MD, MPH, PhD
Institut Pasteur
EHESP

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List of Abbreviations

CA: Conjoint Analysis

CI: Confidence Interval

COVID-19 – Corona Virus Disease-2019

DCE: Discrete Choice Experiment

GERES Groupe d'Étude sur le Risque d'Exposition des Soignants aux agents infectieux

HCWs: Healthcare workers

VE: Vaccine Efficacy

VIP: Vaccine-induced Indirect Protection

VH: Vaccine Hesitancy

VS: Vaccine Safety

PD: Protection Duration

RIS: Recommendation/Incentive Source

OR: Odds Ratio

WHO World Health Organization

Abstract

Quantifying health care workers' preferences around COVID-19 vaccination: a single-profile DCE study in France

Background: HCWs are a priority group to vaccinate against COVID-19 to prevent disease-related absenteeism and nosocomial infection. Analysing their preferences around this vaccination is crucial to understanding suboptimal uptake and suggest potential levers to increase adherence.

Methods: We administered an online single-profile discrete choice experiment (DCE) to a snowballing sample amongst French HCWs recruited from December 2020 to January 2021 through professional organizations. Respondents chose between accepting or rejecting eight hypothetical COVID-19 vaccination scenarios. Vaccine eagerness was evaluated by certainty to refuse or accept vaccination.

Results: Among the 4346 participants, 61.1% gave uniform responses, of which 17.2% were serial non-demanders of COVID-19 vaccine, refusing all eight scenarios. Attributes' level impacts were estimated on the remaining 38.9% of respondents. Among the latter, a strong negative impact on hypothetical vaccine acceptance was observed with 50% vaccine efficacy [compared to 90%: odds ratio 0.05, 95%-CI: (0.04-0.06)], and to a lesser extent with a reference to a benefit-risk balance [compared to absence of severe and frequent side effects: OR 0.40 (0.34-0.46)]. The highest positive impact was the prospective of meeting older people without risk and of contributing to epidemic control [compared to no indirect protection effect: OR 4.10 (3.49-4.82) and 2.87 (2.34-3.50), respectively]. Interaction analyses showed significant but not substantial effect heterogeneity by age group, professional category and study phase. Among serial non-demanders, vaccine eagerness slightly but significantly increased with the prospect of safely meeting older people and contributing to epidemic control; and reduced by lower vaccine efficacy.

Discussion: This study provided insight into preferences around COVID-19 vaccination among HCWs, in particular among those who hesitate or refuse vaccination. These results will be useful to inform vaccine promotion strategies and may help to develop adapted vaccine promotion for HCWs, as the vaccine response against the COVID-19 epidemic will turn into a long-term vaccination strategy.

Key Words: COVID-19, France, vaccination, healthcare workers, DCE, vaccine hesitancy

Abstract in French

Quantification des préférences des professionnels de santé autour de la vaccination de la COVID-19: une étude au choix discret de mono profil en France

Contexte : Les professionnels de santé sont une cible prioritaire de la vaccination contre la COVID-19, pour prévenir les infections nosocomiales ainsi qu'absentéisme lié à la maladie. L'analyse de leurs préférences est cruciale pour comprendre couverture vaccinale sous-optimale actuelle et suggérer les leviers pour augmenter l'adhésion.

Méthodes : Nous avons administré un outil de choix discrets mono-profile à un échantillon de professionnels de santé en France, recueilli entre décembre 2020 et janvier 2021 par système de boule de neige. Les répondants ont choisi, pour une série de situations hypothétiques, entre accepter ou rejeter la vaccination contre la COVID-19. L'envie de se faire vacciner a été quantifiée par la certitude de refuser ou accepter la vaccination.

Résultats : Parmi les 4346 participants, 61.1% ont donné des réponses uniformes à travers tous les scénarios, dont 17.2% des refus. Les impacts des niveaux d'attribues ont été estimés parmi les 38.9% répondants avec décisions variables. Parmi eux, un fort impact négatif sur l'acceptation théorique vaccinale était observé avec une efficacité vaccinale réduite à 50%. [comparé à 90%: odds ratio 0.05, 95%-CI: (0.04-0.06)], et dans une moindre mesure avec la notion d'une balance bénéfice-risque favorable [comparé à l'absence d'effets secondaires sévères et fréquents: OR 0.40 (0.34-0.46)]. L'impact le plus fort venait de la perspective de rencontrer des personnes âgées sans risque et de contribuer au contrôle de l'épidémie [comparé à l'absence de protection indirecte : OR 4.10 (3.49-4.82) et 2.87 (2.34-3.50), respectivement]. Les analyses d'interaction ont montré une hétérogénéité d'effet significative mais non substantielle par groupe d'âge, catégorie professionnel et phase d'étude. Parmi les participants refusant de façon uniforme, l'envie de se faire vacciner a augmenté légèrement mais significativement avec la perspective de rencontrer les personnes âgées sans risque et de contribuer au contrôle de l'épidémie ; et diminué par une efficacité vaccinale réduite.

Discussion : Cette étude permet d'étudier les préférences au tour de la vaccination contre la COVID-19 parmi les soignants, en particulier parmi ceux qui hésitent ou refusent le vaccin. Ces résultats seront utiles pour définir des stratégies vaccinales et adapter promotion du vaccin pour soignants, alors que la réponse vaccinale contre l'épidémie deviendra une stratégie à long-terme.

Mots clés : COVID-19, France, vaccination, professionnels de santé, DCE, hésitation vaccinale

Background

In December 2019, the first case of SARS-CoV-2 was detected in Wuhan, China (1). In less than four months, WHO declared the COVID-19 sanitary crisis a pandemic, causing a shutdown of global proportions not seen in over a century. In the early stages of the outbreak, governments resorted to lockdowns to curve the spread of this highly infectious and novel disease. Even the most extensive and resourceful medical systems experienced the burden of COVID-19 patients, which in some cases needed ICU treatment. After governmental mandated lockdowns and limits on mass gatherings (2), most European countries "flattened the curve" of SARS-CoV-2 cases; however, by fall 2020 cases began to stealthily rise once again, propelling the pandemic into a new phase. In the summer of 2020, to prepare for the then hypothetical second wave of COVID-19 and prevent an even greater public health catastrophe, a survey was launched in France to understand the perceptions to HCWs around the soon to be developed COVID-19 vaccine. This study found a correlation between hypothetical acceptance of COVID-19 vaccination and flu vaccine uptake, even if the latter was not performed annually (3). Among HCWs in France, the seasonal influenza vaccine coverage has been relatively low for more than a decade (4), due to multiple reasons including complacency and lack of confidence for some, and lack of convenience for others (3). Therefore, there is valid concern that this vaccine hesitancy may parallel the COVID-19 vaccination efforts. By mid-June 2021, the COVID-19 vaccine coverage for at least one dose among HCWs in cabinet was estimated at 78.1% and 55.7% for those at nursing homes or other long-term care facilities, (5) higher than the 35% influenza vaccine coverage estimate during 2018-2019 (6). Because there may be differences in uptake between professional categories (7), and between mode of service as exemplified by administration sources, as well as the complication of re-vaccination since booster doses might be required or a novel strain coverage, it will be important to understand which characteristics of the vaccine and / or the vaccination context can make hesitant HCWs decide in favour of COVID-19 vaccination and to optimize communication messages accordingly.

According to a Gallup Poll conducted in 2018, France attained the highest level of vaccine hesitancy in regard to vaccine safety – one out of three disagreeing that vaccines are safe, while ranking second world-wide, with 19% of the population disagreeing that vaccines are effective (8). There has always been scepticism surrounding vaccines, with peaks surrounding controversy around specific events. For example, following the recommendations of WHO from 1991, France launched a Hepatitis B campaign in 1994, which was heavily criticized by the anti-vax movement over both, an exaggeration of the epidemic and particularly condemning the interest of laboratories (9). Distrust of vaccines and their sources has been shown to cause vaccine hesitancy in the French public. Because of an early detection of symptoms of vaccine hesitancy (10), France has been able to monitor the propagation of hesitancy amongst its population since the early 2000's. This makes it a special case to follow in order to better understand the mechanics of the rise in vaccine scepticism and in turn combat hesitancy. This is especially important when analysing the current vaccination perception as COVID-19 vaccines continue to be globally administered.

Recent research has described vaccine hesitancy as a continuum between complete acceptance and refusal, while hesitant individuals have varying opinions depending on several factors, such as type of disease and vaccine (11). Vaccine hesitancy has seen a rise globally leading to the WHO's Strategic Advisory Group of Experts (SAGE) to create a definition for this phenomenon. The SAGE's definition mentions that factors such as "complacency, convenience, and confidence" influence vaccine hesitancy (12). It is important to note that this low uptake of vaccination excludes cases due to lack of available resources. To further describe the root of vaccine hesitancy, discrete choice experiments (DCE) and conjoint analyses (CA) have increasingly been used to study preferences around vaccines and vaccination (13, 14). While both of these methods elicit preference choices surrounding a topic of choice, conjoint analyses origins stem from psychology and elicit a ranking system of preferences, whereas DCEs originate from economics; the latter is based on random utility theory (RUT), which measures choice behaviour that is not always explicit (15) Similarly, single-profile DCEs vary from the classical approach in that they focus on binary selection of a single profile, in this case, one vaccine showcasing different combinations of attribute levels. These "choice-tasks" mimic decision-making in real-life, which make them ideal to use in preference analysis. Incorporating individual preferences into the vaccine strategies development has been supported by three key arguments (16). First, since there are currently multiple vaccine options, it presents an opportunity to allow for informed choices, including accepting or not different options. Second, preference surveys exhibit the core assumption that aligning the characteristics of a medical device (in this case vaccinations) with the expectations of the population will optimize uptake. Third, acknowledgement of public preferences could foster trust towards public authorities, which is a key determinants of vaccination intention (17). In a previous study, researchers developed a single profile discrete choice experiment (DCE) that included seven vaccine attributes (14). These attributes and their corresponding levels were created first via literature review and narrowed down to most important through discussion amongst co-authors. Through this study, researchers were able to distinguish not only detrimental factors, but also motivating elements that affected vaccine intention. For example, wearing a badge to demonstrate vaccination status showed a negative impact on vaccination intention. Therefore, DCE's, along with other preference surveys, provide the opportunity to elicit preferences and allow us to understand not only motivating, but also detrimental factors, which are of equal importance, that impact vaccine uptake.

The rise in vaccine hesitancy enters a new level when healthcare workers themselves are sceptical. This is particularly alarming, as healthcare professionals are seen as a highly trusted source of information regarding vaccination (18). Unfortunately, doctors are not immune to vaccine scepticism, and understanding the root of HCWs vaccine hesitancy is primordial not only to control the current pandemic, but also to prevent further outbreaks of vaccine preventable diseases.

Aims and Objectives

This study was developed with the aim to better understand the impacts of preferences relating to vaccine attributes amongst HCWs in France.

Primary Objectives:

- Estimate impact of preferences (Odds Ratios) of vaccination attributes: efficacy, safety, protection, duration of protection, and recommendation/incentive source - and individual characteristics, such as flu vaccination uptake during 2019-2020, on hypothetical vaccine intention.
- Estimate marginal effects of vaccine attribute levels.
- Identify interaction amongst vaccine attribute and participant characteristics, and amongst attributes themselves.

Secondary/Exploratory Objectives

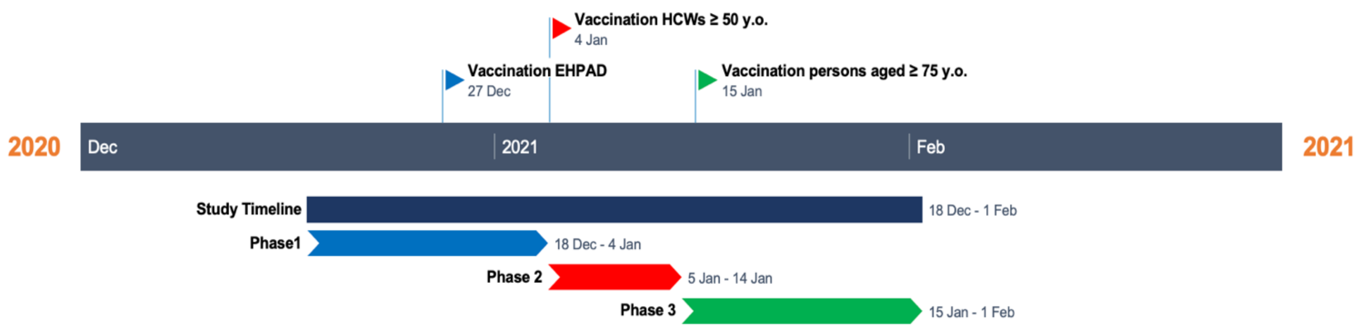
- Compare evolution of hypothetical COVID-19 vaccine acceptance amongst HCWs as new national vaccine regulations evolved.
- Evaluate vaccine utility and estimate predicted vaccine percentage uptake in scenario specific simulations (i.e., mRNA, AstraZeneca, future vaccines).
- Evaluate eagerness to vaccinate through certitude data per scenario

METHODS AND MATERIALS

Study Design and Participant Inclusion

We conducted and developed a cross-sectional longitudinal panel study among HCWs in France that took place between December 18, 2020 through February 1, 2021. This survey included a single profile DCE which is a specific choice format where respondents repeatedly choose between two options: accept or reject the hypothetical profile (e.g., vaccine) (14, 19). This format allows calculating the marginal effects (and odds ratio) of vaccination characteristics on theoretical acceptance and predict the demand for hypothetical vaccines through utility calculations. The Research Group for the Prevention of Occupational Infections in Healthcare Workers (GERES), through the Sphinx online survey platform, published this anonymous online questionnaire which was propagated throughout France by different healthcare networks. The survey was open to HCWs throughout metropolitan France and the DOMs, albeit the latter contributed to a small representation. Through the “snowballing sampling” technique effect, the questionnaire reached a total of 9580 participants of diverse medical careers and fields. Since participants forwarded the questionnaire across their own networks, response rate could not be estimated. The participants were separated into three different phases, according to the date of survey entry, corresponding to new data on vaccine roll-out in France. The different phases are split from December 18, 2020 to January 4, 2021 from January 5 to January 14,2021, and lastly from January 15 to February 1, 2021.

Figure 1. Study Timeline. Vaccine roll-out in France stating December 2020, corresponding to study phases.



Questionnaire

The survey was separated into multiple parts. The first included background information on the participants (i.e., profession and socio-demographic characteristics). This was followed by questions to collect participant characteristics (flu vaccine 19-20, COVID-19 infection, etc). Afterward, through pseudo-random selection, the survey varied in the following section – participants answered either the KAP (Knowledge, Attitudes, and Practices) or the ConjointVac questionnaire. The latter included a DCE to better understand the hypothetical acceptance of the COVID-19 vaccine amongst HCWs across France. At study start, vaccine efficacy data had been published or announced by AstraZeneca, Pfizer and Moderna. In France, vaccination in nursing homes (Pfizer) had started late December 2020, while vaccination for HCWs aged ≥50 years started on January 4, 2021. The vaccine campaign targeting persons ≥75 years of age was launched starting January 15, 2021 (using Pfizer and Moderna). During the entire study period, no travel or work restrictions were imposed, but a curfew was in place 20h-6h, which was extended to 18h-6h starting January 15, 2021, as well. Lastly, the survey concluded with several questions regarding COVID-19 vaccination (HAS recommendation, priority information). The survey took approximately 10 minutes to complete and DCE choice tasks were mandatory in order to ensure complete survey responses, and therefore obtain a comprehensive preference analysis.

Design of Discrete Choice Experiment (DCE)

We designed the DCE tool (**Table 1**) based on a literature review on vaccine intention and vaccine-related preferences among HCWs (14), COVID-19 vaccine intention available for the general population (20) and a study on vaccine acceptance conducted during summer 2020 among HCWs in France (3). Members of GERES contributed expertise regarding HCW occupational medicine and provided real-world insight into vaccination barriers and levers. Those who participated in the DCE were given a short reminder of the immediate hypothetical vaccine against COVID-19 and then asked to make a binary decision for or against accepting immediate vaccination, presented through a series of imaginary scenarios (choice tasks, **Figure 1**), with varying attribute's levels (21). Immediately after the choice question, they were asked the level of certitude of their decision, with 0 being the lowest and 10 being the highest. As participants make decisions of each vaccine scenario, or choice-task, DCE's allow the attribute levels to be analysed and estimate utility of specific scenarios.

The full-factorial design encompassing all five attributes with their corresponding variables resulted in 324 different combinations, from which we selected 24 scenarios for an efficient design (based on *a priori* assumptions regarding the direction of the effects, **Table 1**) using NGENE® software. The set of 24 scenarios were blocked into three versions of eight scenarios to which participants were pseudo-randomly directed (according to the choice of a geometrical figure). We included an interaction term between two attribute levels based on the hypothesis that in the scenario referring to the control of the epidemic, duration of protection beyond one year would have lower effect on acceptance. The tool was pilot tested in think-aloud sessions with HCWs.

Figure 2. Example choice task

You are participating in an information session regarding the vaccine organized for healthcare workers. Following the information session, you will be able to immediately get vaccinated against COVID-19 at no cost. Below is the information regarding the vaccine.

Scenario 1	
	➢ The vaccine allows prevention of 90% of COVID-19 cases, including severe forms ➢ The vaccination will allow you to meet without risk older people of your family and patient roster. ➢ The vaccine safety is strictly monitored in a joint effort of European countries. ➢ The vaccination will probably be effective for a duration of 3 years. ➢ 80% of healthcare workers in other European countries have been vaccinated.

☐ I accept the vaccine

☐ I do not accept it

Certainty of your decision ______ (0=not at all certain; 10=absolutely certain

Attribute description and assumptions

- Vaccine Efficacy (3 levels). We hypothesized that compared to the information on 90% vaccine efficacy, 50% would have a lower hypothetical acceptance, while adding the specification “including against serious forms of COVID-19” would yield a higher acceptance. We utilized the second level as the reference (90% efficacy), since it allowed us to comment on the effect that a decrease in efficacy (50% efficacy) would have on the hypothetical vaccine acceptance.

-Vaccine Safety (3 levels) described different types of information regarding the safety of the proposed vaccine. We hypothesized that information on strict safety monitoring in a joint effort of European countries would have a positive effect on hypothetical COVID-19 vaccine acceptance compared to risk negation (“no severe and frequent adverse events in clinical trials”), while reference to a benefit-risk balance – although positive - would reduce it.

- Indirect Protection (4 levels) described different information regarding vaccine impact beyond individual protection. We hypothesized that compared to “not known yet whether protects against infection”, stating that there was no such indirect protection would decrease acceptance, while reference to control of the epidemic and the possibility to meet elderly friends and family would increase acceptance.

- Protection Duration (3 levels). We hypothesized that, compared to annual vaccination, not knowing the duration of protection would be dissuasive and a duration of 3 years would be motivating.

- Recommendation/Incentive Source (3 levels). We hypothesized that compared to a request from the Ministry of Health that HCWs get vaccinated, a recommendation formulated by professionals and researchers without conflict of interest with vaccine manufacturers would be motivating, as would an information - referring to social conformism - that 80% of HCWs in other European countries have been vaccinated.

Data Analysis

We used bivariate and multivariate models to assess the association between participant characteristics and the frequency of theoretical vaccination acceptance across scenarios. Variables were included in the final model if they significantly interacted with one of more attributes at the 0.05 level. Using a panel random effects logit model, we then estimated preference impacts of attribute levels. We privileged the random effects model over fixed effects after performing a Hausman test (result: p>0.1941).

Using interaction terms, we explored interactions between attributes and participant characteristics, as well as between attributes themselves. We report separate preference impact estimates where significant interactions were found (**Table 5 & 6a-b**).

Uniform respondents (i.e., participants who accept or refuse scenarios in all eight scenarios) do not contribute any information to logit models. In the present study, certitude levels ranged from 0 to 10, 0 indicating “not at all certain,” and 10 indicated “absolutely certain.” We created a variable describing the eagerness to get vaccinated corresponding to certainty values, where certainty values from refused scenarios were transformed into negative values. Thus, individuals refusing vaccination with a certainty of 10 would have a score of -10 on the vaccine eagerness scale, and those accepting vaccination with a certainty of 10 would have a score of +10. A negative variation in certainty (e.g., decreasing from 10 to 7) among serial non-demanders (those refusing the vaccine in all scenarios) is interpreted as an increase in vaccine eagerness. We used a panel linear regression model to analyse each attribute’s impact on vaccine eagerness. Additionally, we created a variable for phase of study participation, according to the roll-out of the vaccination campaign described above: December 18, 2020 to January 4, 2021, January 5 to January 14, 2021, and lastly from January 15 to February 1, 2021 (**Figure 1**).

Predicted Uptake

We calculated the utility of specific scenarios that appeared of practical relevance: 1) current communication on COVID-19 vaccination, 2) optimized communication on mRNA vaccines, 3) AstraZeneca vaccine recommended to ≥55-year-old persons (assuming lower VE against variant strains and a confirmed severe side effects), and 4) anticipated communication about future upcoming vaccines with recent licensure and uncertainty around the vaccine profile (**Annex, Table 3**). We estimated the utility of specific scenarios based on beta coefficients of each attribute (relative to the reference level) from the global xtlogit model: utility_sc = Beta_k * Xk, where k is the level of attribute (0=reference; 1=other level); and calculated the predicted acceptance among non-uniform respondents for each specific scenario:

$$predicted\ accept = 1 \div [1 + e^{-utility\_sc}]$$

Data analysis was performed using Stata/IC 16.0.

Ethics

The study protocol was approved by the IRB of CHU St Etienne (N°IRBN1092021/CHUSTE) and the database was registered by EHESP French School of Public Health according to the GRDP regulation. Because the data collection was observational, collected no sensitive and only self-declared biomedical information, no informed consent was required according to French law (loi Jardé). Participants visiting the study website saw the complete study information and agreed to study participation before starting the questionnaire. Study participation was anonymous without any risk of indirect identification.

RESULTS

Descriptive statistics

Among the 4346 participants assigned to the DCE (45.4%), all completed the questionnaire. Sixty-two percent of survey participants were younger than 50 years of age and 76% were female. Nurses represented 21.9%, nurse assistants and other short-trained HCWs with patient contact 11.2% and biomedical professions (including physicians, mid-wives, pharmacists and biologists) 27%. Administrative and technical career HCWs accounted for 24.6% (**Table 2).** The plurality of the participants came from the Auvergne-Rhone-Alpes region, with 18.7%, followed by Haut de France and Ile-de-France accounting for 13.3% and 11.1%, respectively. The remaining of 56.7% of the respondents were distributed amongst the rest of the 15 regions. Those who believed having a risk factor for severe COVID-19 accounted for 18.9% and 12.5% reported having been infected with the virus. The percentages indicating influenza vaccination during the 2019-2020 flu season were 76.1%, 51.2%, and 30.4%, respectively, among doctors, nurses and nursing aids, compared to the nationally estimates during 2018-19 of 72.2%, 35.9%, 20.9%, respectively (6). Participants worked in hospital settings (61.2%), nursing homes or other long-term care institutions (16.2%), ambulatory/seeing patients outside any care institution setting (15.4%) or mixed exercise (6.0%).

Preferences around vaccine acceptance

Across scenarios, vaccination was on average accepted by 60.1% of participants, ranging from 44.6% in the least favourable and 82.8% in the most favourable scenario (**Appendix Table 1**). Uniform decisions were made by 61.1% of participants (n=2655), with 17.2% (n=747) always refusing and 43.9% (n=1908) always accepting vaccination. When removing participants with uniform decisions, vaccination was theoretically accepted by 55.3% of participants across all scenarios.

Preferences estimated for participants with non-uniform decisions were all statistically significant, except for Recommendation/Incentive Source “experts without conflict of interest.” (**Table 3**). The strongest negative impact was observed with Vaccine Efficacy “50%” (OR 0.05, 95%-CI 0.04-0.06). This was followed by Protection Duration “unknown duration” [OR 0.49 (0.42-0.57)] and Individual Protection “individual protection only” (OR 0.47 [0.39-0.56]). The most positive impacts were amongst the Individual Protection attribute: “meet older people” with OR 4.10 [3.48-4.82] and “control of epi” with OR 2.87 [2.35-3.50].

Based on marginal effects among the full sample, Vaccine Efficacy “50%” reduced vaccine acceptance by 21 percentage points, while Indirect Protection “meet older people” increased it by 7 percentage points, and “control of epidemic” by 6 percentage points. Moreover, mentioning the benefit-risk ratio and “strictly monitored across the EU” abated vaccine acceptance by 5 percentage points. Similarly, among non-uniform respondents, lower vaccine efficacy of 50%, compared to 90%, showed a decrease of 38 percentage points, safely meeting older people increased acceptance by 23 percentage points, while contributing to the control of the epidemic showed an increase of 17 percentage points, and finally mentioning a benefit-risk ratio and having the safety of the vaccine be strictly monitored across the European Union, both showed a decrease of 15 percentage points, respectively. (**Table 4, Figures 3a-b**).

Figure 3a. Full sample (N=4346).

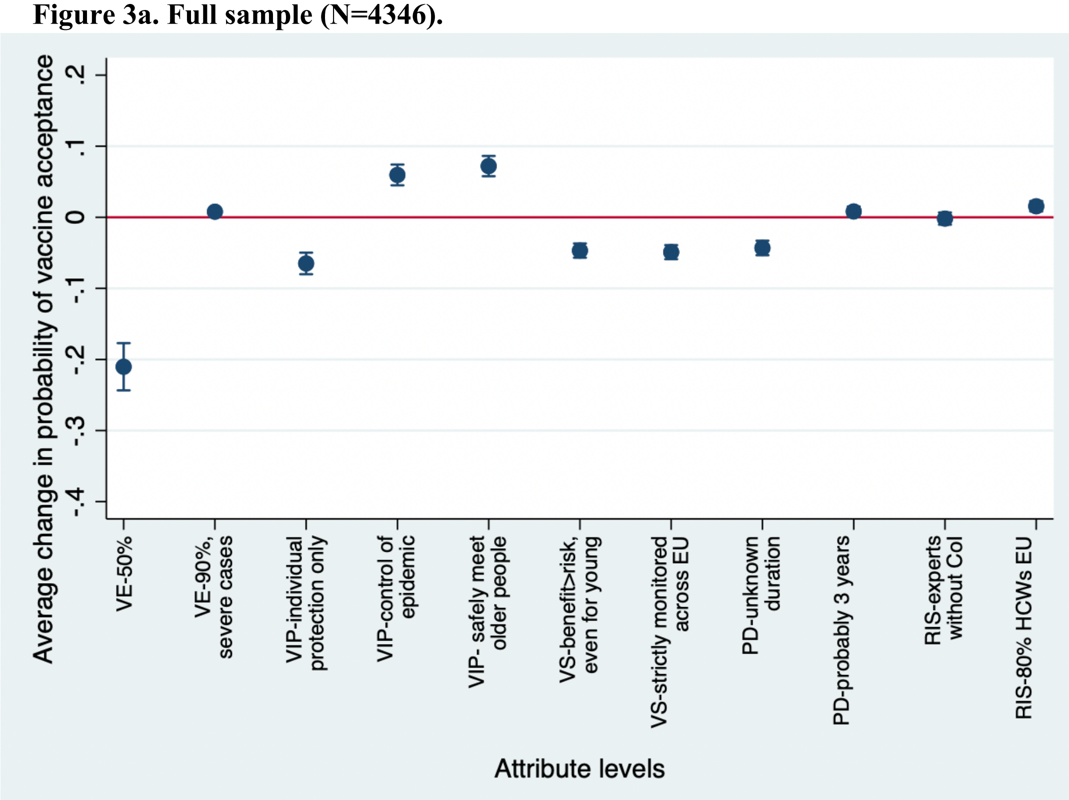
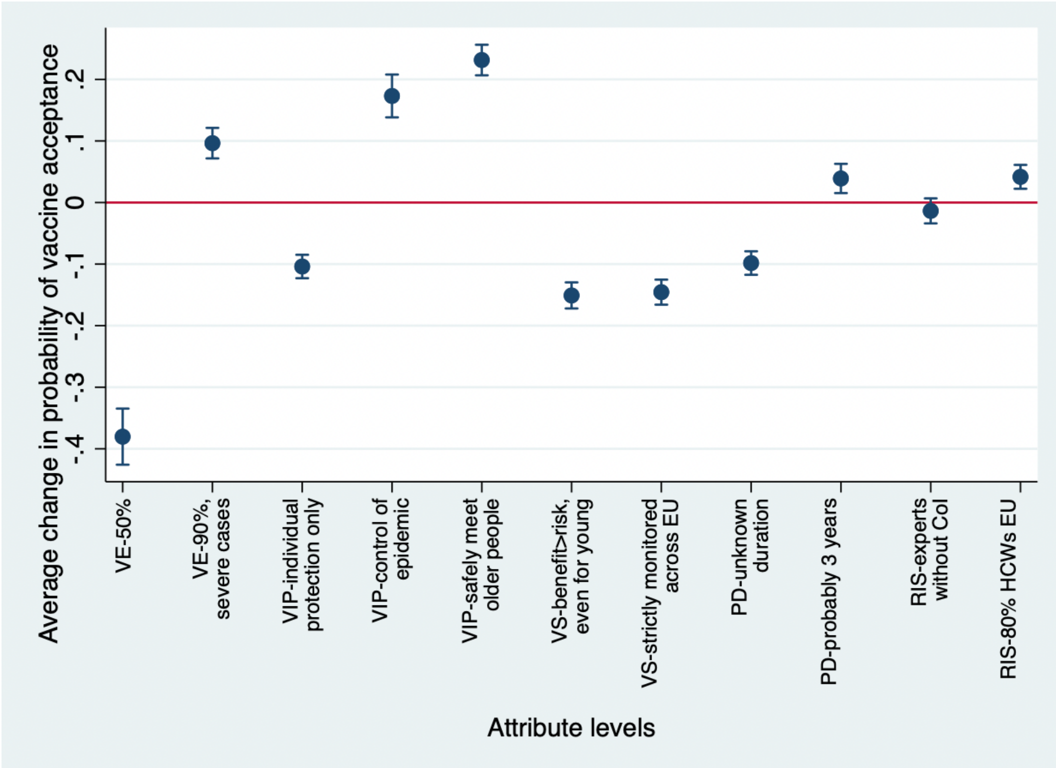


Figure 3b. Non-uniform respondents only (N=1691).



Figures 2a-b: Average marginal effects (change in probability of vaccine acceptance) of attribute levels on hypothetical acceptance of vaccination against COVID-19.
ConjointVac survey among 4346 healthcare workers in France, December 18, 2020 to February 1, 2021.

Attributes: VE "Vaccine Efficacy," VIP "Vaccine Indirect Protection," VS "Vaccine Safety," PD "Protection Duration," RIS "Recommendation/Incentive"
Lecture note: Among all participating HCW, Vaccine Efficacy "50%" instead of "90%" decreased hypothetical vaccine acceptance by 21 percent points, whereas it decreased by 38% amongst non-uniform respondents only.

Table 3. Main effects for attributes of hypothetical COVID-19 vaccination acceptance (binary outcome) and ß-coefficient for vaccine eagerness: degree of change in certitude of a given scenario (-10 to 10) by attribute level. ConjointVac Survey among healthcare workers in France, from December 18, 2020 to February 1, 2021

Attributes	Accept vaccination		Vaccine eagerness		Vaccine eagerness	
	N = 1691 (non-uniform respondents)		N = 4346 (all respondents)		N = 747 (serial non-demanders)	
	OR	95%-CI	ß-coefficient	95%-CI	ß-coefficient	95%-CI
Vaccine Efficacy (VE)						
VE 90%	Ref					
VE 50%	0.05***	[0.04,0.06]	-2.89***	[-3.001; -2.78]	-0.36***	[-0.45; -0.28]
VE 90%, severe cases	1.70 ***	[1.50,1.94]	0.48***	[-0.38;0.59]	0.08*	[0.01;0.16]
Vaccine Indirect Protection (VIP)						
VIP - Unknown	Ref					
VIP – Individual Protection only	0.47 ***	[0.39;0.56]	-0.76***	[-0.90; -0.61]	-0.09	[-0.20;0.19]
VIP – Control of Epidemic	2.87 ***	[2.34;3.50]	0.89***	[0.73;1.04]	0.20***	[0.09;0.32]
VIP – Meet Older People	4.10 ***	[3.49;4.82]	1.35***	[1.22;1.48]	0.28***	[0.19;0.38]
Vaccine Safety (VS)						
VS- Absence of severe & frequent side-effects	Ref					
VS - Benefit > Risk, even for young	0.40 ***	[0.34;0.46]	-0.77***	[-0.89; -0.64]	-0.06	[-0.15;0.03]
VS Strictly monitored across EU	0.38 ***	[0.33;0.44]	-0.89***	[-1.01; -0.77]	-0.06	[-0.15;0.13]
Protection Duration (PD)						
PD- Annual Vaccine	Ref					
PD - Unknown duration	0.49 ***	[0.43;0.57]	-0.62***	[-0.74; -0.50]	-0.08	[-0.17; -0.01]
PD – Probably 3 years	1.19 *	[1.02;1.37]	0.18**	[0.06;0.30]	0.04	[-0.05;0.13]
Recommendation/Incentive Source (RIS)						
RIS - MoH requests	Ref					
RIS - Experts without conf. of interest	0.97	[0.84;1.12]	0.07	[-0.04;0.19]	0.10*	[0.01;0.18]
RIS - 80% of other EU have been vaccinated	1.32 ***	[1.17;1.50]	0.31***	[0.20;0.42]	0.08	[-0.001,0.16]

OR: odds ratio. 95%-CI: 95% confidence interval. *p-value <0.05; **p-value <0.01; ***p-value ≤0.001

Accept vaccination preference weights (OR) estimated from varied responders (38.9%).

Vaccine eagerness, ß-coefficients estimated from all responders, and negative uniform responders (17.2%).

Table 4. Marginal effects for attribute levels of hypothetical COVID-19 vaccination acceptance (binary outcome). ConjointVac survey among 4346 healthcare workers in France, from December 18, 2020 to February 1, 2021.

	Accept vaccination			
	Full sample (N = 4346)		Non-uniform respondents (N = 1691)	
Attributes	dy/dx	95%-CI	dy/dx	95%-CI
Vaccine Efficacy (VE)				
VE 90%	Ref		Ref	
VE 50%	-0.21***	[-0.24; -0.18]	-0.38***	[-0.43; -0.33]
VE 90%, severe cases	0.01 ***	[0.01;0.01]	0.01***	[0.07; 0.12]
Vaccine Indirect Protection (VIP)				
VIP - Unknown	Ref		Ref	
VIP – Individual Protection only	-0.06 ***	[-0.08; -0.05]	-0.10***	[-0.12; -0.08]
VIP – Control of Epidemic	0.06 ***	[0.05;0.07]	0.17***	[-0.14; 0.21]
VIP – Meet Older People	0.07***	[0.06; 0.09]	0.23***	[0.21; 0.26]
Vaccine Safety (VS)				
VS- Absence of severe & frequent side-effects	Ref		Ref	
VS - Benefit > Risk, even for young	-0.05***	[-0.06; -0.04]	-0.15***	[-0.17; -0.13]
VS Strictly monitored across EU	-0.05 ***	[-0.06; -0.04]	-0.15***	[-0.17; -0.13]
Protection Duration (PD)				
PD- Annual Vaccine	Ref		Ref	
PD - Unknown duration	-0.04***	[-0.05; -0.03]	-0.01***	[-0.12; -0.08]
PD – Probably 3 years	0.01 *	[0.001;0.02]	0.04***	[0.02;0.06]
Recommendation/Incentive Source (RIS)				
RIS - MoH requests	Ref		Ref	
RIS - Experts without confl. of interest	-0.002	[-0.01;0.01]	-0.01	[-0.03;0.01]
RIS - 80% of other EU have been vaccinated	0.02 ***	[0.01;0.02]	0.04***	[0.02;0.06]

dy/dx: marginal effects. 95%-CI: 95% confidence interval. *p-value <0.05; **p-value <0.01; ***p-value ≤0.001

Lecture note: In the entire sample, Vaccine Efficacy "50%" decreased hypothetical vaccine acceptance by 21 percentage points, whereas the same attribute level decreased it by 38% amongst the participants who varied in responses across scenarios.

Vaccine Eagerness

Among the entire sample of participants, including the 17.2% serial non-demanders, those who refused all scenarios presented, and 43.9% serial-demanders, referring participants who accepted all eight scenarios, the average level of vaccine eagerness (on a -10 to 10 scale) in scenarios ranged from -0.78 to 5.86 (**Annex Table 1, SM Figure 1**). Analyses based on vaccine eagerness in the entire sample showed a similar pattern of positive and negative preference impacts as the analysis on vaccine acceptance among non-uniform respondents, with strongest negative impact from move one up, as Vaccine efficacy ("50%", ß -2.89, [-3.01, -2.78]) and the strongest positive impact from Indirection protection "[meet older people", ß 1.35, (1.22,1.48)].

Among negative uniform respondents, all preference impacts showed a similar direction of impact, but effects were substantially weaker compared to the full sample and mostly insignificant. We observed a significant negative impact from Vaccine Efficacy "50%" [ß -0.36 CI (-0.45, -0.28)]; and significant positive impacts from Indirect protection "control of epidemic" [ß 0.20 [0.09-0.32)]) and "meet older people" (ß 0.28 [0.19-0.38]). Moreover, Recommendation/Incentive Source "experts without conflict of interest" had a significant positive impact (ß 0.10 [0.01-0.18]).

Interaction

Significant interactions with individual characteristics were observed for all attributes (**Table 5 &6a-b),** in particular for the attribute Vaccine Efficacy and characteristics age and phase. For example, the positive impact of the Indirect Protection attribute levels, "control of epidemic" was lower among the 35- to 49-year-old [OR 2.53 (CI 0.37-0.76)] and ≥50-year-old age group (OR 2.43 (CI 0.35-0.74)] than the 18- to 34-year-old group [OR 4.77 (3.44,6.61)]. A similar trend was observed for "meet older population."

We observed a trend to lower negative impact of Vaccine Efficacy "50%" in later study phases [phase 2, OR 0.05, (0.48-0.87)] and phase 3, [OR 0.04, (0.39-0.72) compared to 0.07 OR, (0.059,0.09) in phase 1] and a trend to lower impact of "control of epidemic": phase 2, OR 2.46 [0.47-0.93] and phase 3 OR 1.94 [0.37-0.73] compared to phase 1 OR 3.73 [2.88,4.84]. A similar trend was observed for "meet older population." Additionally, among nurse assistants, a recommendation by an expert group without conflict of interest had a significant negative attribute impact [OR=0.67, (0.42-0.95)].

In assessing the interaction between attributes (**Annex Table 2**), the positive impact of Protection Duration "probably 3 years" increased and became significant in scenarios with Indirect Protection "control of epidemic" [OR 1.98, (1.18-3.43)].

Table 5. Interaction effects between attribute levels and sociodemographic characteristics.
ConjointVac Survey among 4346 healthcare worker non-uniform respondents (n=1691), in France from December 18, 2020 to February 1, 2021

		Gender		Professional category					Age		
Vaccine Attribute		Female	Male	Nursing	Nursing Assistant	Other paramedical	Bio-Medical	Admin./ Technical	18-34	35-49	50+
		Odds Ratio [95%-CI]									
Efficacy	90%			Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
	50%			0.05 [0.04;0.07]	0.07	0.05	0.06	0.05	0.07 [0.05;0.09]	0.05	0.05*
	90%, severe cases			1.93 [1.53;2.43]	1.87	1.81	1.18**	1.60	1.84 [1.46;2.33]	1.82	1.42
VIP	unknown								Ref	Ref	Ref
	Individual only								0.53 [0.39;0.71]	0.42	0.55
	control of epidemic								4.77 [3.44;6.61]	2.53***	2.43***
	meet older people								6.84 [5.10;9.17]	3.76***	3.08***
Safety	absence of severe/freq. se	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
	benefit>risk, even for young	0.37 [0.32;0.44]	0.52*	0.35 [0.27;0.45]	0.41	0.52*	0.60**	0.34	0.33 [0.25;0.43]	0.46*	0.39
	strictly monitored across	0.37 [0.31;0.43]	0.51*	0.39 [0.30;0.49]	0.45	0.47	0.46	0.32	0.28 [0.21;0.36]	0.42**	0.46**
Duration	Annual Vaccine								Ref	Ref	Ref
	Unknown duration/efficacy								0.67 [0.52;0.87]	0.49	0.40**
	Probably 3 years								1.24	1.36	0.94
Source	MoH requests			Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
	Experts w/out conf of interest			1.04	0.67*	1.11	0.85	1.12	0.79	0.96	1.14*
	80% of EU			1.47 [1.16,1.84]	1.16	1.43	1.23	1.25	1.16	1.44	1.31

Asterisks represent the significance level of interaction terms of the given subgroup with the attribute level: * <0.05; ** <0.01; *** ≤ 0.001
[95%-CI], 95%-confidence intervals of the main effects in the reference subgroup, if not overlapping 1 (p<0.05). Lecture note: ≥50-year-old participants have significantly (p≤ 0.001) lower preference weights (OR) to contributing to epidemic control compared to those in the reference group (18- to 34-year-old participants). The effect of "control of epidemic" is significant (p<0.05) only among the group of 18- to 34-year-old participants.

Table 6a. Interaction effects between attribute levels and participant characteristics.
ConjointVac Survey among healthcare worker non-uniform respondents (n= 1691) in France, from December 18, 2020 to February 1, 2021

Vaccine Attribute		Flu Vaccine 19-20		Infected by SARS-CoV-2		Phase		
		no	yes	no	yes	1	2	3
		Odds Ratio						
Efficacy	90%	Ref	Ref	Ref	Ref	Ref	Ref	Ref
	50%	0.06 [0.05;0.07]	0.05	0.05 [0.04;0.06]	0.09***	0.07 [0.06;0.09]	0.05**	0.04***
	90%, severe cases	1.91 [1.62;2.23]	1.41*	1.70 [1.48;1.95]	1.72	1.74 [1.45;2.08]	1.64	1.60
VIP	unknown			Ref	Ref	Ref	Ref	Ref
	Individual only			0.50 [0.42;0.65]	0.30*	0.50 [0.39;0.63]	0.43	0.48
	control of epi			2.87 [2.33;3.52]	2.90	3.73 [2.88;4.84]	2.46*	1.94***
	meet older people			3.87 [3.27;4.58]	6.11*	5.19 [4.16;6.48]	3.06**	3.42*
Safety	absence of severe/freq. side effects	Ref	Ref			Ref	Ref	Ref
	benefit>risk, even for young	0.36 [0.29;0.43]	0.48*			0.34 [0.28;0.42]	0.52**	0.42
	strictly monitored across	0.40 [0.34;0.48]	0.38			0.34 [0.28;0.42]	0.43	0.43
Duration	Annual Vaccine	Ref	Ref					
	Unknown duration/ efficacy	0.53 [0.45;0.64]	0.46					
	Probably 3 years	1.42 [1.18;1.70]	0.95**					

Asterisks represent the significance level of interaction terms of the given subgroup with the attribute level: * <0.05; ** <0.01; *** ≤ 0.001
[95%-CI], 95%-confidence intervals of the main effects in the reference subgroup, if not overlapping 1 (p<0.05)
Lecture note: We observe, later phases impact a lower preference of control of epidemic, compared to participants from the first phase.

Table 6b. Interaction effects between attribute levels and participant characteristics.
ConjointVac Survey among healthcare worker non-uniform respondents (N=1691) in France, from December 18, 2020 to February 1, 2021

Vaccine Attribute		Confidence in Crisis Management			Worry for Epidemic		
		low	medium	high	low	medium	high
		Odds Ratio					
Efficacy	90%	Ref	Ref	Ref	Ref	Ref	Ref
	50%	0.09 [0.07;0.11]	0.05***	0.05***	0.14 [0.09;0.21]	0.06***	0.04***
	90%, severe cases	1.72 [1.40;2.12]	1.70	1.62	2.18 [1.53;3.12]	1.55	0.68
VIP	unknown	Ref	Ref	Ref			
	Individual only	0.55 [0.41;0.72]	0.53	0.36*			
	control of epi	2.82 [2.12;3.76]	3.07	2.59			
	meet older people	4.88 [3.76;6.33]	4.15	3.07*			
Safety	absence of severe/freq. side effects	Ref	Ref	Ref			
	benefit>risk, even for young	0.41 [0.32;0.52]	0.36	0.50			
	strictly monitored across	0.49 [0.39;0.61]	0.35*	0.38			
Duration	Annual Vaccine				Ref	Ref	Ref
	Unknown duration/ efficacy				0.64 [0.43;0.97]	0.47	0.48
	Probably 3 years				2.10 [1.40;3.17]	1.13**	1.09**

Asterisks represent the significance level of interaction terms of the given subgroup with the attribute level : * <0.05; ** <0.01; *** ≤ 0.001
95%-CI, 95%-confidence intervals of the main effects in the reference subgroup are shown if they do not overlap 1 (p<0.05)
Lecture note: We observe those with medium or high level of worry of epidemic have significantly (p<0.01) lower preference weights (OR) for longer duration of protection, compared to those with low worry of epidemic

Predicted acceptance

Among participants with non-uniform decisions, the predicted acceptance of specific scenarios was 93.8% for optimized communication on mRNA vaccines; 5.4% for vector-based vaccines recommended to ≥55-year-old persons and 65.2% for future COVID-19 vaccines with recent licensure (**Annex Table 3**). For future COVID-19 vaccines with recent licensure, the predicted acceptance varied substantially between professional categories: 58.3% among nurses, 53.6% among nurse assistants, 77.7 % among other paramedical professions, 77.1% among biomedical professions and 58.7% among administrative and technical careers. For mRNA vaccines and AstraZeneca (and other viral vector vaccines with similar attributes levels), the predicted acceptance did not vary extensively between professional categories. For mRNA vaccines the following predicted percent acceptances were observed: 92.7% amongst nurses, 94.8% amongst nurse assistants, 90.6% amongst other paramedical, 95.0% amongst biomedical professions, and 94.4% amongst administrative and technical career. For AstraZeneca, the following predicted percent acceptances were observed per professional subgroup in the same order, 2.6%, 5.8%, 6.8%, 16.1%, 3.2%, where the largest variance was shown under biomedical professions.

DISCUSSION

Summary of Results and Interpretation

In this single-profile DCE among HCWs in France, through evaluating preferences surrounding COVID-19 vaccination, we observed significant negative preference weight around Vaccine Efficacy “50%” (compared to 90%) making it a main driver of vaccine hesitancy, compared to the elements tested. This coincides with previous findings from other DCEs performed in the general adult population (22). This attribute level dissuades HCWs from their intention to get vaccinated against COVID-19. As aforementioned, vaccine hesitancy is a spectrum that varies according to disease. In the case of the COVID-19, the speed at which the vaccine was created has threatened both its efficacy and safety. The media has ardently highlighted efficacy levels through headlines, which could have contributed to the importance of this attribute to discouraging vaccine intention. Moreover, as new SARS-CoV-2 strains naturally evolve, the situation regarding the reference of Vaccine Efficacy becomes more realistic. For example, even with variants, the Pfizer vaccine benefits from a >90% efficacy, whereas even with two doses, the AstraZeneca vaccine did not show protection against mild to severe cases caused by the B.1.351 variant (23). In France, AstraZeneca was prioritized for HCWs during the initial phase, during which it stated having 76 % efficacy (24), which could have potentially contributed to the slow uptake of the vaccine. Comparatively, under Vaccine Safety, the negative preference impact surrounding the mention of a benefit-risk ratio shows the importance of abstaining from mentioning in communications surrounding vaccine promotion. This is explained through loss aversion theory, which states that losses (in this case consequences of potential side-effects due to the vaccine) have more impact than gains (25). The wording “benefit-risk” itself implies the confirmation of a risk, and people may prefer negative consequences from omitting vaccination, rather than negative consequences due to lack of vaccination

(26). On the other hand, prior research has placed high importance on the benefit-risk ratio, stating its mention is imperative for the public to make an informed decision (27). Wherefore, further research is needed to explore how this benefit-risk notion can be translated into a more acceptable concept for communication, for example utilizing decision aids to reduce decisional conflict (28). In addition, our results show that the attribute Vaccine-Induced Indirect Protection is an important motivator for vaccination, since we observe the two strongest positive impacts on vaccine acceptance on contributing to the epidemic control and being able to safely meet older people.

Furthermore, we found interaction effects amongst attribute levels and participant characteristics, such as age and phase. Under Vaccine Indirect Protection (VIP), "control of epidemic" and safely being able to meet older people have a weaker positive effect as age increases. It is interesting that older HCWs place lower value in being able to meet older people, including those amongst their patient rosters. This could represent altruism under another form of sympathy, as HCWs opt for creating personal utility rather than collective utility (29). Additionally, the negative impact of Vaccine Efficacy "50%", which increases as phase increases could pinpoint to the emergence of vaccine variants. By the end of February, the Alpha variant, with origins in the UK, had become the predominant strain in France (30). The finding of a strong preference against a vaccine with limited efficacy is important in the current context of ongoing genetic diversification of SARS-CoV-2, which may lead to reduced vaccine effectiveness, and consequently lower acceptance of COVID-19 vaccination. Hence, fear surrounding the novel, sometimes more contagious and causing severe symptoms (30), variants can attribute this significant negative impact increase. Counter-intuitively, amongst nursing assistants, when Recommendation/Incentive Source came from a group of "experts without conflict of interest," vaccine intention was significantly lower compared to nurses. This finding provides room for further qualitative research to better understand the root of hesitancy in this subgroup. Finally, only little heterogeneity of preferences was identified across subgroups. This suggests that the recommendations emerging from our results can be applied to HCWs in general, without risk of negative impact in a specific subgroup.

In regard to attribute interactions amongst themselves, duration of vaccine protection comprising probably 3 years is only significant when assessed jointly with contributing to epidemic control, which could be explained by the routine HCWs are typically accustomed to of yearly vaccinations (i.e., flu). In this case, the protection duration is not necessarily a motivating factor, until it is affected by their contribution to the control of the epidemic as a whole. Other separate interesting findings included analysis on negative uniform respondents and percentage predicted acceptance. Because of similar preference impacts (albeit smaller) were found amongst serial non-demanders compared to the full sample, we can utilize vaccine communication promotion evenly across those hesitant towards COVID-19 vaccination as well as those who show positive inclinations.

In regard to predicted COVID-19 vaccine uptake, our study allowed us to estimate a high percentage of predicted acceptance for mRNA vaccines, such as Moderna and Pfizer, low for AstraZeneca, which has been exclusively recommended for >55 years of age and HCW, and moderate uptake for future vaccines with recent licensure and according to uncertainty about effectiveness against infection/transmission, duration of protection and safety profile. When examining predicted vaccine uptake by profession, once again we see little heterogeneity across groups (with the exception of a future vaccine with recent licensure), which corroborates that vaccine recommendations, in this case modelled using different combinations of attribute levels, can be applied to the general HCW population. Since the epidemic is rapidly evolving, our utility estimation is useful allowing us to model the attributes of new vaccines accordingly.

Study Limitations

The results reported herein should be considered in the light of the following limitations. Firstly, the snow-ball method used to recruit survey participants not only inherently encompasses selection bias, but also, it does not allow to estimate response rate. The latter is important to obtain a sample representative of the population we are analysing – HCWs. The seasonal coverage of the flu vaccine (2019-20 season) in our sample (51.9%) suggest that participants were more favourable to vaccination compared to the HCW population in France (flu coverage for 2018-19 season estimated at 35%). This is also highlighted by the high percentage of participants who uniformly chose to accept vaccination (43.9%). We therefore cannot provide valid prevalence estimates for HCWs in France, only investigate attribute impacts on preferences and associations. However, our study allowed us to explore the preferences amongst serial non-demanders, those who refused all scenarios and therefore could be classified as highly hesitant. Our results showed that impact on preferences can be applied to the full HCW population. Secondly, since this study was performed amongst French HCWs, our results may not apply to other populations across the world. As aforementioned, across European nations, France has the highest vaccine scepticism regarding safety as well as second highest in terms of efficacy (8). Nonetheless, recently WHO has declared Vaccine Hesitancy (VH) one of ten major global health threats (31); thus, highlighting the importance of research on VH at a global scale. Moreover, although our results are specific to the French population, the topics relating to vaccine hesitancy, for example, complacency, lack of confidence, and collective responsibility, have been observed world-wide (32); therefore, our study can provide an insight into global vaccine promotion amongst HCWs. Finally, preference studies are known to overestimate willingness, since by their nature, imaginary scenarios are not necessarily representative of real-life choices. Our DCE study was designed to evaluate the situation at the start of the COVID-19 vaccine campaign, before vaccine-roll out began, and as new information regarding the virus and vaccines emerge, other attributes may become more important to evaluate and preferences may change over time.

Despite these limitations, our study points towards several elements of improved COVID-19 vaccination promotion for HCWs, in particular those who are hesitating to get vaccinated: focusing on and selecting vaccines with high efficacy; insisting on consequences for every day social life, such as safely meeting older people, and selecting vaccines for HCWs that substantially reduce infection or transmission; avoiding the notion of “risk-benefit balance,” but providing information on both benefits and risks. HCWs in France are a group composed of multiple professionals with different levels of higher education, vaccine hesitancy and risk exposure. Their preferences around vaccination have the potential to reach the general population, particularly in terms of specific professional aspects and knowledge.

Recommendations

Between March 2020 and March 2021, more than 95,000 deaths were associated with COVID-19 in France (30) As it emerges from its third national confinement, France continues to struggle to control the current evolving epidemic, which can be ameliorated through vaccination (33). According to Santé Publique France and GERES, by the beginning of March 2021, the COVID-19 infection rate amongst HCWs stands at 7.6% (34), whereas the infection rate for the general population in France is estimated to be 4.73% (35). The discrepancy between these infections rates, one being almost double the other, highlights the importance of vaccine promotion amongst HCW as a priority group. As aforementioned, HCWs are not only at increased risk of the disease itself, but also of transmission to vulnerable populations who are part of their patient roster. Furthermore, research has shown that the vaccination tendencies of general practitioners, are significantly associated with their recommendations to patients (36). We can infer a similar pattern across of the health professional careers. Thus, highlighting the importance of understanding HCWs vaccine preferences, which likely to permeate throughout the general population. Therefore, through the implementation of vaccine promotion catered to age level, focused on vaccine efficacy, and avoiding notions of benefit-risk ratio, vaccine hesitancy amongst HCWs can be contained; hence, contributing to the containment of the sanitary crisis.

Conclusion

This study provides insight into preferences around COVID-19 among HCWs, in particular among those who hesitate about or refuse this vaccine. By combining the exactitude and specificity of DCE’s methodology in outlining scenario-decisions and the concepts of social decision-making, the potential to understand how decisions are made is vast; therefore, it allows further exploration of vaccine hesitancy amongst not only healthcare professionals, but also, the general population. DCE’s are emerging to be the privileged method to understand vaccine preferences. Because they are a quantitative method that measures the importance of each attribute level, we are able to derive what factors have a positive and negative effect on vaccine intention, and similarly, based on attribute levels, what types of vaccines would benefit from a high acceptance, and which would struggle to receive optimal uptake. As previously discussed, Louviere et al. outlines the “latent” preference that is not seen by the researcher yet lies within the participant (15). DCE’s go beyond ranking different alternatives and allow the survey participant to elicit their preference over hypothetical alternatives (37), which resemble real-life decisions. Particularly, single-profile DCEs are an attractive tool that allows researchers to clearly define the importance of each attribute, and to analyze preferences by either rejecting or accepting the presented scenario. Our results show that certain vaccine elements do have an impact on vaccine intention, will be useful to inform vaccine promotion strategies and may help to develop adapted vaccine recommendations for HCWs as the vaccine response against the COVID-19 epidemic will turn into a long-term vaccination strategy. For example, avoiding the notion of benefit-risk ratio, while providing high efficacy vaccines, as well as highlighting HCWs impact on the control of epidemic and being able to safely meet older people. It is important to accentuate the current worldwide vaccination campaign's promising results in reducing COVID-19 infection, demonstrating that vaccination is a key player in controlling the epidemic (33, 38, 39). Hence, understanding the root of vaccine hesitancy amongst HCWs is primordial, not only to control the current pandemic, but also to avoid outbreaks of other vaccine-preventable diseases.

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Conflict of interest
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Table 1. Attributes and attribute levels with hypotheses on the expected effects.

Attributes	Levels	Assumptions
Vaccine Efficacy **(VE)**	The vaccine has 90% efficacy.	Reference
	The vaccine has 50% efficacy.	H_1: OR < 1
	The vaccine allows prevention of 90% of COVID-19 cases, including severe forms.	H_2: OR >1
Indirect Protection **(VIP)**	It is unknown if the vaccine prevents virus transmission to those around you in case of infection.	Reference
	If you are infected, the vaccine will stop you from becoming sick from the disease, but it will not stop you from spreading the virus to those around you.	H_3: OR < 1
	With the vaccination, you will contribute to the control of the COVID-19 epidemic.	H_4: OR> 1
	The vaccination will allow you to meet without risk older people of your family and patient roster.	H_5: O R> 1
Vaccine Safety **(VS)**	The clinical trials show an absence of severe and frequent side effects.	Reference
	The scientific data suggests that even if you are young, the benefit that the vaccine provides is much larger to the hypothetical risk that we cannot yet rule out.	H_6: OR > 1
	The vaccine safety is strictly monitored in a joint effort of European countries.	H_7: OR > 1
Protection Duration **(PD)**	Annual vaccine will be necessary.	Reference
	The duration and efficacy of the vaccine are yet unknown.	H_8: OR < 1
	The vaccination will probably be efficacious for a duration of 3 years.	H_9: OR > 1
Recommendation/Incentive Source **(RIS)**	The ministry of health asks healthcare workers to get vaccinated.	Reference
	The vaccination recommendation is issued by a group of health professionals and scientists without any conflict of interest in relation to the vaccine producers.	H_{10}: OR > 1
	80% of healthcare workers in other European countries have been vaccinated.	H_{11}: OR > 1

OR: Odds Ratio

Table 2. Participant characteristics. ConjointVac survey among 4346 healthcare workers in France, December 18, 2020 to February 1, 2021.

				Hypothetical acceptance	Serial demander [1] n=1908	Serial non-demander [1] n=747	Bivariate model	Multivariate parsimonious model [2]
		N	Column %	%	N (row %)	N (row %)	OR [95%-CI]	OR [95%-CI]
Total		4346	100	NA	43.9	17.2	NA	NA
Gender	Women	3302	76	67.60	1321 (40)	623 (18.9)	Ref	Ref
	Men	1044	24	80.84	587 (56.2)	124 (11.9)	5.74*** [4.28; 7.69]	2.53*** [1.93;3.32]
Age	18-34	941	21.6	60.68	296 (31.5)	236 (25.1)	Ref	Ref
	35-49	1764	40.6	69.44	744 (42.2)	306 (17.4)	3.54*** [2.50;5.0]	2.18*** [1.64;2.90]
	50+	1641	37.8	78.00	868 (52.9)	205 (12.5)	11.32*** [7.98;16.05]	3.75 *** [2.79;5.05]
Profession	Nurse	951	21.9	65.10	327 (34.4)	187 (19.7)	Ref	Ref
	Nurse assistant	485	11.2	42.27	97 (20)	191 (39.4)	0.12*** [0.07;0.18]	0.42 *** [0.28;0.63]
	Other paramedical	672	15.5	69.64	280 (41.7)	129 (19.2)	1.87** [1.25;2.81]	2.60*** [1.83;3.70]
	Biomedical	1170	27	88.89	784 (67.01)	67 (5.7)	32.0 *** [22.5;45.5]	7.32*** [5.25;10.21]
	Admin./technical	1068	24.6	69.67	420 (39.3)	173 (16.2)	1.82*** [1.27;2.6]	1.18 [0.86;1.60]
Works in nursing home	No	3640	83.8	72.99	1682 (46.2)	578 (15.9)	Ref	Ref
	Yes	706	16.2	59.35	226 (32.01)	169 (23.9)	0.20*** [0.14;0.29]	0.61** [0.45;0.82]
Believes having a risk factor	no	3264	79.8	71.14	1449 (44.4)	556 (17)	Ref	Ref
	Yes	825	20.2	72.12	370 (44.5)	129 (16.8)	1.2 [0.85;1.65]	..
Previously infected by SARS-CoV-2	No	3803	87.5	71.79	1702 (44.8)	638 (16.8)	Ref	Ref
	Yes	543	12.5	63.72	206 (38)	109 (20.1)	0.44 [0.30;0.66]	0.72 [0.52;1.00]
Flu Vaccination 2019-20	No	2091	48.1	55.00	570 (27.3)	608(29.1)	Ref	Ref
	Yes	2255	51.9	85.4	1338 (59.3)	139 (6.2)	41.2*** [32.1;52.7]	8.51*** [6.74;10.75]
Would accept COVID-19 vaccine	No	1786	41.1	31.5	108 (6.1)	744 (41.7)	Ref	—
	Yes	2560	58.9	98.2	1800 (70.3)	3 (0.1)	277.5 [222.94;345.36]	— —

Confidence in crisis management [3]	Low	1187	27.3	45.83	262 (22.1)	454 (38.3)	Ref	Ref
	Medium	1771	40.8	73.35	767 (43.3)	230 (13)	19.6*** [14.5;26.4]	7.15*** [5.44;9.39]
	High	1388	31.9	88.83	879 (63.3)	63 (4.6)	161.42*** [116.0;222.4]	28.4*** [20.88;38.72]
Worry [4]	Low	442	10.2	42.76	108 (24.4)	190 (43)	Ref	Ref
	Medium	1283	29.5	67.11	516 (40.2)	239 (18.6)	16.9*** [10.6;27.0]	4.03*** [2.70;6.00]
	High	2621	60.3	77.30	1284 (49)	318 (12.1)	50.9*** [32.9;78.9]	5.83*** [3.98;8.55]

*p-value <0.05; **p-value <0.01; ***p-value ≤ 0.001

[1] Uniform respondents are defined as those either refusing (serial non-demanders) or accepting (serial demanders) vaccination on all eight scenarios.

[2]Multivariate parsimonious model does not include COVID-19 vaccination intention due to collinearity with outcome variable.

[3] Confidence in authorities to manage sanitary and economic crisis due to COVID-19, assessed as 0 to 10: low (0-3), medium (4-6), high (7-10).

[4] General worry about COVID-19 epidemic; assessed as 0 to 10, low (0-3), medium (4-6), high (7-10).

Lecture note: 18.9% of women and 11.9% of men refused (serial non-demander) the hypothetical vaccine in all scenarios.

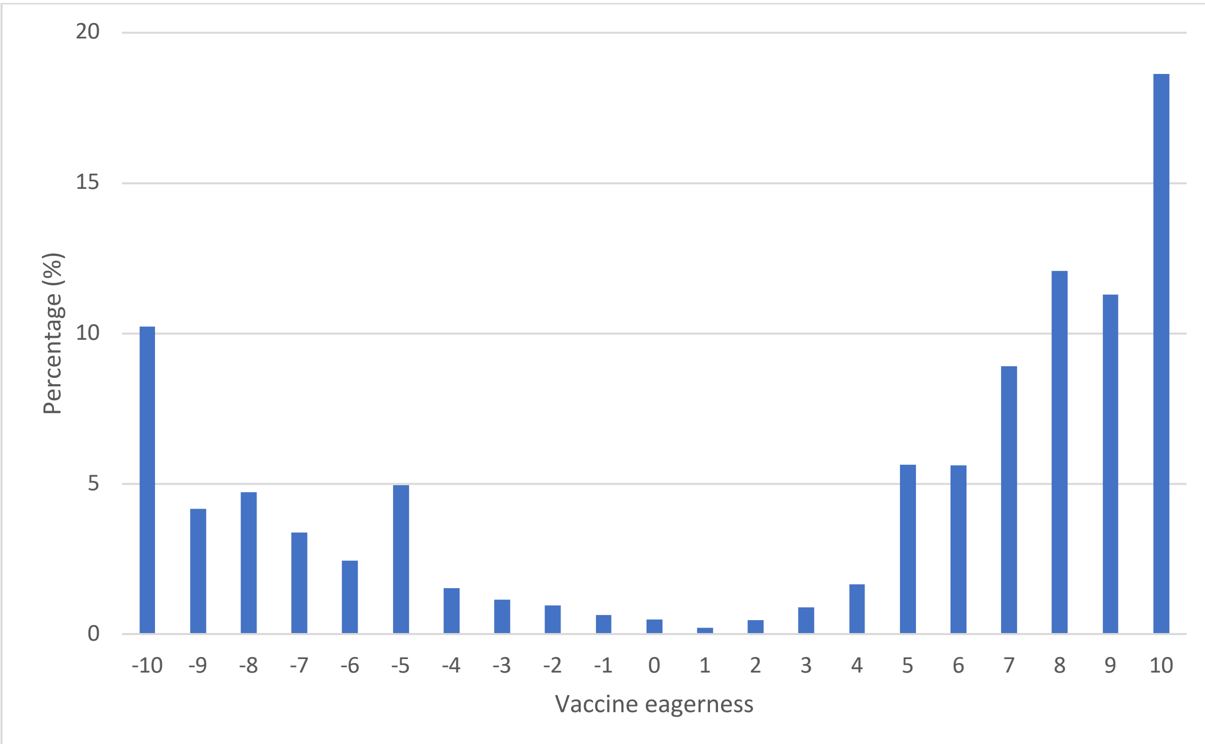
ANNEX

SM. Table 1. Hypothetical acceptance of COVID-19 vaccination and vaccine eagerness (mean) in binary response by scenario.

Scenario	Scenario Description*	Acceptance (0-100%)	Average vaccine eagerness; certitude (-10 to 10)
1	1-1-2-3-2	68.55	3.32
2	3-1-3-1-2	70.63	3.60
3	1-1-3-2-2	44.58	-0.78
4	2-4-1-2-2	73.45	4.06
5	1-3-3-3-1	54.91	0.79
6	2-2-1-1-2	62.92	2.19
7	1-2-2-1-2	44.69	-0.78
8	2-1-2-2-3	66.69	2.93
9	1-3-2-1-1	56.19	0.98
10	3-4-1-3-1	82.77	5.86
11	3-4-3-1-3	77.26	4.74
12	2-1-3-3-1	64.82	2.47
13	3-3-2-2-1	70.42	3.44
14	1-3-1-2-3	59.81	1.62
15	3-2-1-2-1	68.11	3.01
16	2-4-2-1-1	76.08	4.56
17	3-2-3-2-1	62.75	2.05
18	1-4-2-2-3	54.97	0.92
19	1-2-1-3-3	49.76	0.15
20	1-4-3-3-2	57.62	1.38
21	2-3-1-1-3	78.39	4.84
22	2-2-3-1-3	65.70	2.47
23	3-1-2-3-3	68.70	3.12
24	3-3-1-3-2	82.07	5.64

*Attribute combination performed by NGENE® software.

SM. Figure 1. Vaccine eagerness distribution; certitude across scenarios (-10 to 10)
ConjointVac Survey among 4346 health care workers in France, from December 18, 2020 to February 1, 2021.



SM Table 2. Interaction effects between attributes Indirect Protection and Protection Duration.
ConjointVac survey among 4346 healthcare workers in France, December 18, 2020 to February 1, 2021.

	Indirect Protection attribute		
	Individual protection only OR	Control of epidemic OR [95%-CI]	Safely meet older people OR
Protection Duration attribute			
Annual	Ref	Ref	Ref
Unknown duration	1.1	0.96	0.78
Probably 3 years	0.98	1.98 ** [1.18-3.43]	1.04

OR, Odds ratios representing the effect of PD attribute levels compared to “annual”
* <0.05; ** <0.01; *** ≤ 0.001; p-values represent the significance level of interaction terms (compared to VIP “individual protection only”)
95%-CI, 95%-confidence intervals of the main effects in the given subgroup are shown if they do not overlap 1 (p<0.05)

SM. Table 3. Predicted acceptance of specific vaccination scenarios and by professional category. Estimates apply only to participants with variable choice (non-uniform responders). ConjointVac Survey among 4346 health care workers in France, from December 18, 2020 to February 1, 2021.

Specific scenarios	Estimated Utility	Predicted acceptance (%)
1) Optimized communication on mRNA vaccines	2.71	93.79
VE "90%, severe cases", VIP "control of epi", "absence of severe & freq. side-effects", PD "annual", and RIS "Ministry of Health"		
Nurses	2.54	92.69
Nursing Assistants/Aids	2.91	94.83
Other paramedical careers	2.26	90.56
Biomedical professions (doctors/midwives)	2.95	95.01
Administrative/technical careers	2.82	94.42
2) AstraZeneca (recommended for over 55 years old)*	-2.87	5.37
VE "50%", VIP "unknown", VS "benefit>risk, even for young", PD "unknown", and RIS "Ministry of Health"		
Nurses	-3.61	2.63
Nursing Assistants/Aids	-2.78	5.82
Other paramedical careers	-2.63	6.75
Biomedical professions (doctors/midwives)	-1.65	16.06
Administrative/technical careers	-3.40	3.22
3) Future vaccines with recent licensure	0.63	65.18
VE "90%, sc", VIP "unknown", VS "benefit>risk, even for young", PD "unknown", and RIS "80% HCWs EU"		
Nurses	0.34	58.34
Nursing Assistants/Aids	0.14	53.57
Other paramedical careers	1.25	77.73
Biomedical professions (doctors/midwives)	1.22	77.12
Administrative/technical careers	0.35	58.70

*Model restricted to ≥50-year-old participants