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"Please, you go first!" preferences for a COVID-19 vaccine among adults in the Netherlands

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ABSTRACT

Background: Vaccination is generally considered the most direct way to restoring normal life after the outbreak of COVID-19, but the available COVID-19 vaccines are simultaneously embraced and dismissed. Mapping factors for vaccine hesitancy may help the roll-out of COVID-19 vaccines and provide valuable insights for future pandemics.

Objectives: We investigate how characteristics of a COVID-19 vaccine affect the preferences of adult citizens in the Netherlands to take the vaccine directly, to refuse it outright, or to wait a few months and first look at the experiences of others.

Methods: An online sample of 895 respondents participated between November 4th and November 10th, 2020 in a discrete choice experiment including the attributes: percentage of vaccinated individuals protected against COVID-19, month in which the vaccine would become available and the number of cases of mild and severe side effects. The data was analysed by means of panel mixed logit models.

Results: Respondents found it important that a safe and effective COVID-19 vaccine becomes available as soon as possible. However, the majority did not want to be the first in line and would rather wait for the experiences of others. The predicted uptake of a vaccine with the optimal combination of attributes was 87%, of whom 55% preferred to take the vaccine after a waiting period. This latter group tends to be lower-educated. Older respondents gave more weight to vaccine effectiveness than younger respondents.

Conclusions: The willingness to take a COVID-19 vaccine is high among adults in the Netherlands, but a considerable proportion prefers to delay their decision to vaccinate until experiences of others are known. Offering this wait-and-see group the opportunity to accept the invitation at a later moment may stimulate vaccination uptake. Our results further suggest that vaccination campaigns targeted at older citizens should focus on the effectiveness of the vaccine.

1. Introduction

The COVID-19 pandemic forms an unprecedented public health and economic crisis. A safe and effective vaccine against COVID-19 could prove critical in establishing herd immunity (Motta, 2021). At the end of 2020, the first vaccines were approved and the first vaccination programmes were launched. The primary focus of these programmes is to reach a sufficient vaccine uptake among the public for achieving herd immunity (Neumann-Böhme et al., 2020). Having a vaccine available and vaccination programme in place does not automatically guarantee high enough vaccination rates. Uptake of the H1N1 vaccine during the 2009 influenza pandemic, for instance, was relatively low (Blasi et al., 2012). It is, therefore, important to understand the conditions under which people are willing to be vaccinated against COVID-19

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(Neumann-Böhme et al., 2020).

People's preferences for a COVID-19 vaccine have previously been examined using discrete choice experiments (DCEs) (Borriello et al., 2021; Craig, 2021; Dong et al., 2020; Leng et al., 2021) and other preference elicitation methods (Motta, 2021; Catma and Varol, 2021; García and Cerda, 2020; Kreps et al., 2020; Sarasty et al., 2020; Tervonen et al., 2020; Wang et al., 2021). These studies investigated how the uptake of a COVID-19 vaccine was affected by characteristics such as effectiveness, location, availability, country of production, price, duration of protection and risk of side effects. In most of these studies respondents were asked to choose between vaccines with different characteristics or to opt-out when the vaccines offered were below their acceptance threshold (Borriello et al., 2021; Craig, 2021; Kreps et al., 2020). Such studies provide information about factors influencing vaccination preferences and the proportion of citizens that intends to take or refuse the vaccine. However, with the COVID-19 vaccine, part of the vaccine hesitancy observed seems to be related to the short period of vaccine development compared to traditional vaccines, resulting in distrust and increased worries about the occurrence of side effects (Borriello et al., 2021; Chou and Budenz, 2020; Fadda et al., 2020). Hence, it is anticipated that some citizens may not want to be the first in line but rather wait and learn from the experiences of others before deciding to vaccinate or not.

Previous COVID-19 vaccination preference studies did not offer respondents this wait-and-see option, while the inclination to wait with vaccinating may carry relevant information for policy makers aiming to develop efficient and effective vaccination programmes – not just in the context of the current pandemic but also for future pandemic situations. The key objective of our study is therefore to extend on previous work by investigating preferences for COVID-19 vaccination allowing for a waiting period. Specifically, we conducted a discrete choice experiment (DCE) to investigate how characteristics of a COVID-19 vaccine affect the proportion of adult citizens in the Netherlands that will take the vaccine directly, refuse it outright, or prefer to wait a few months and first look at the experiences of others. The study was conducted before anything was known about the effectiveness of COVID-19 vaccines and well before vaccination prioritization schedules were published.

2. Methodology

The core idea behind DCEs is that individuals' preferences for a product (here a COVID-19 vaccine) are driven by preferences for the characteristics (so-called 'attributes') of that product (Lancaster, 1966). The relative importance of attributes can be assessed by presenting respondents a series of choice tasks in which they are asked to select the preferred alternative from a set of two or more alternatives with varying combinations of attribute levels (Hensher et al., 2005). The attributes and attribute levels for the current study were selected based on a four-step process, including a review of previous vaccination preference elicitation studies (Borriello et al., 2021; Craig, 2021; Veldwijk et al., 2014), a discussion with policy makers, feedback from experts, and feedback from a convenience sample pilot study (see Appendix 1 for more details). Four attributes were eventually selected: 1) The percentage of vaccinated individuals protected against COVID-19; 2) The month in which the vaccine would become available to the respondent; 3) The number of cases of mild side effects; 4) The number of cases of severe side effects. Table 1 provides an overview of the final set of attributes and levels.

Once we defined the attributes and the initial set of attribute levels, we constructed a Bayesian D-efficient design for our DCE (Kessels et al., 2011). We incorporated prior knowledge in the design that acknowledges that higher effectiveness and earlier availability is generally preferred over lower effectiveness and later availability, whereas a lower risk of mild and severe side effects is preferred over a higher risk. Furthermore, we expressed uncertainty around our expectations in a multivariate prior parameter distribution. The final design consisted of 32 choice tasks which were grouped into four blocks of 8 choice tasks. Appendix 2 shows the design together with a detailed specification of the design efficiency.

Participants received information on the study purpose, questionnaire content, data storage and who had access to their data before starting the survey. Written informed consent was obtained at the start of the survey. After providing informed consent, participants were presented with eight choice tasks. In each choice task, they were asked to select which of the two vaccines on offer they would prefer (i.e. forced choice). Fig. 1 provides an example of a choice task (translated into English, original choice task in Dutch).

Respondents were then asked "Would you choose to be vaccinated with your selected vaccine?" and offered three response options: 1) "Yes, I would take this vaccine immediately if it is available"; 2) "Yes, I would take the vaccine, but I would like to wait a few months and first look at the experiences of others"; 3) "No, I would definitely not take this vaccine". We asked respondents to assume the vaccines on offer were properly tested and approved by health authorities. We also asked them to assume that people who are not vaccinated would not be allowed to travel to countries with many COVID-19 infections or would be required to go into quarantine when arriving and upon return. People who were vaccinated could travel without restrictions. Finally, we asked respondents to assume that it is not possible to take one of the vaccines on offer first and the other vaccine later as the number of available vaccines is limited.

After the choice tasks, we asked participants who indicated that they would like to wait a few months before taking the vaccine in at least one of the eight choices how many months they would like to wait. To investigate whether different groups in the population weighs the characteristics of a COVID-19 vaccine differently, we collected information about socio-demographic characteristics (e.g., age, gender, education). Respondents were also asked whether they are usually invited for the annual influenza vaccination programme (as an indication of belonging to medical risk groups) and, if so, whether they accepted the invitation last year (as an indication of willingness to vaccination). Finally, respondents were asked how they rate the risk of hospitalization or dying after being infected with COVID-19 ("no risk", "low risk", "reasonable risk", "high risk" or "extremely high risk"), whether they had been infected with COVID-19 and whether they found the government's response to the pandemic appropriate, insufficient or

Table 1
Overview of the attributes and their levels as included in the discrete choice experiment.

Attribute	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
1. Decrease in the number of people becoming ill from the coronavirus among people who have received the vaccine	50%	60%	70%	80%	90%			
2. When will the vaccine be available for you?	3 months from now	5 months from now	7 months from now	9 months from now	11 months from now	13 months from now		
3. Number of cases of mild side effects (such as headache, painful arm and slight fever) per 1,000,000 vaccinations	10,000	20,000	50,000	100,000	200,000	350,000	500,000	700,000
4. Number of cases of severe side effects requiring hospitalization (such as allergic reaction or inflammation of the blood vessels) per 1,000,000 vaccinations	5	10	25	50	100	500	1000	2000

	Vaccine A	Vaccine B
Decrease in the number of people becoming ill from the coronavirus among people who have received the vaccine	Among vaccinated people, the number of people falling ill drops by 90%.	Among vaccinated people, the number of people falling ill drops by 50%.
When will the vaccine be available for you?	In 13 months	In 3 months
Number of cases of mild side effects (such as headache, painful arm and slight fever) per 1,000,000 vaccinations	20,000 out of 1,000,000 (**2%**)	100,000 out of 1,000,000 (**10%**)
Number of cases of severe side effects requiring hospitalization (such as allergic reaction or inflammation of the blood vessels) per 1,000,000 vaccinations	2,000 out of 1,000,000 (**0.2%**)	1,000 out of 1,000,000 (**0.1%**)

Fig. 1. Example of a choice screen as presented to respondents.

exaggerated.

The DCE was performed among adult citizens (≥18 years) of the Netherlands between November 4th and November 10th, 2020. Study participants were recruited from an internet panel (Kantar Profiles) with the objective to be representative of the reference population with regard to age, gender and education. Participants were paid a small incentive to complete the survey. The Human Research Ethics Committee of TU Delft approved our study protocol (nr. 1300).

To derive the marginal utility that respondents obtain from the attributes of a COVID-19 vaccine, we estimated a series of panel mixed logit (PML) models with a linear-in-the-parameters utility function using the Hierarchical Bayes (HB) technique in the JMP Pro 16 Choice platform (based on 10,000 iterations, of which the last 5000 were used for the actual estimation; SAS Institute Inc., Cary, NC, USA). A PML model is a logit model that assumes that the utility parameters differ randomly across persons and thus accounts for the preference heterogeneity between respondents for (the attributes of) the vaccine (Train, 2009). Following standard practice, we adopted a multivariate normal distribution for the utility parameters with no correlation between the attributes to accommodate the unobserved heterogeneity in the respondents' preferences We also estimated the influence of observed respondent characteristics or covariates on the average preferences by enlarging the PML models in the vaccine attributes with interaction terms between the attributes and the covariates. Finally, to interpret the model results, we computed marginal rates of substitution (MRS) and their 95% confidence intervals (CIs) using the Krinsky and Robb method (Krinsky and Robb, 1986, 1990), which is a parametric bootstrap method that involves taking simulated draws from a multivariate normal distribution. We took 10,000 draws from the multivariate normal parameter distribution with means given by the mean estimates and covariance given by the estimated covariance matrix of the parameters, and calculated MRS values for each draw. We obtained mean MRS values by taking the median (0.5 percentile) and 95% CIs by taking the 0.025 and 0.975 percentiles (Bliemer and Rose, 2013).

First, we analysed the forced choice data obtained from the first choice task, in which respondents selected one of the two vaccines on offer. Second, we analysed the data from the follow-up question asking whether respondents would accept, refuse or rather wait to take the vaccine they had selected. We therefore dichotomized this response variable into two new variables: an 'accept' variable containing the choices for direct acceptance of the selected vaccine versus the opt-out of direct acceptance (being the waiting and vaccine refusal choices), and a 'wait' variable containing the choices for waiting to take the selected vaccine versus the opt-out of waiting (being the vaccine acceptance and refusal choices). We estimated opt-out PML models for each of these two variables where the opt-out coefficient measures the extent to which respondents wish to either opt-out of direct vaccine acceptance in the 'accept' model or opt-out of waiting in the 'wait' model. A positive opt-out coefficient means that respondents are in favour of opting out. We then used these two opt-out models to predict uptake percentages for vaccines with different characteristics.

3. Results

A total of 1187 respondents started the survey and 1014 respondents completed it. We excluded 119 respondents (11.7%) because they filled out the survey too quickly (i.e., in less than a third of the median time of 15 min) or provided the same answer (i.e., option A or B) in each choice task. We conducted our analyses on survey data from 895 respondents. Table 2 reports the socio-demographic characteristics and shows that the sample is representative of the adult population of the Netherlands in terms of gender and age, but not education (Appendix 3 provides more details of the sample characteristics). Older respondents (65+) on average spent more time on conducting the survey than younger respondents aged 18–34 year: 19.5 min vs 14.0 min, respectively.

The analysis of the forced choices revealed that respondents considered all attributes to be important in the choice between the two vaccines. Based on the model estimates presented in Table 3 and the entire multivariate normal parameter distribution, we determined using the Krinsky and Robb procedure that respondents are willing to wait an additional month for a vaccine that is 3.3% (95% CI: 3.0–3.7%) more effective or reduces the occurrence of mild and severe side effects with 43,368 (95% CI: 38,693–48,456) and 147 (95% CI: 131–165) per 1,000,000 vaccinations, respectively.

From the model estimates presented in Table 3 we can infer that respondents are willing to wait an additional month for a vaccine that is 3.3% more effective (i.e., 0.3880/0.1162) or reduces the occurrence of mild and severe side effects with 43,111 and 147 per 1,000,000 vaccinations (i.e., 0.3880/0.0090 and 0.3880/2.6355), respectively.

When allowing for non-linear effects in all attributes in a categorical PML model analysis, it is of interest to zoom in on the importance of when the vaccine is available. Fig. 2 reveals that respondents' preferences are non-linear in the number of months until the vaccine is available, although there is a preference for faster availability overall. Specifically, respondents are indifferent between the vaccine becoming available after 3 or 5 months, while they have a strong preference for a vaccine after 11 months compared to a vaccine after 13 months.

Table 2
Socio-demographic characteristics of the sample and adult population.

Characteristics	Sample	Adult population	Chi-Squared test
Gender			
Male	47.9%	49.3%	Statistic 0.5324
Female	51.7%	50.7%	P-value 0.4656
Age			
18–24 years	8.9%	10.9%	Statistic 9.4175
25–34 years	14.6%	15.8%	P-value 0.1514
35–44 years	14.9%	14.8%	
45–54 years	16.9%	18.0%	
55–64 years	19.2%	16.7%	
65–74 years	15.1%	13.7%	
75 years and older	10.4%	10.1%	
Education			
Lower education	38.6%	28.5%	Statistic 44.8490
Middle education	30.9%	36.8%	P-value 0.0000
Higher education	30.5%	34.6%	

Table 3
PML model estimates for the full sample: mean, standard deviation (SD), 95% credible interval and statistical significance of the attribute effects obtained from likelihood ratio (LR) tests.

Model term	Mean (SD; subject SD)	95% credible interval	LR Chi-square	P-value
Increase in the effectiveness of the vaccine with 1%	0.1162 (0.0062; 0.1343)	[0.1043; 0.1284]	383.432	<.0001
Availability of the vaccine is delayed one month	−0.3880 (0.0206; 0.5043)	[−0.4303; −0.3486]	409.703	<.0001
Increase of cases of mild side effects (such as headache, painful arm and slight fever) per 1 out of 1000 vaccinations	−0.0090 (0.0004; 0.0166)	[−0.0098; −0.0082]	378.117	<.0001
Increase of cases of severe side effects requiring hospitalization (such as allergic reaction or inflammation of the blood vessels) per 1 out of 1000 vaccinations	−2.6355 (0.1434; 3.2922)	[−2.9306; −2.3665]	383.263	<.0001

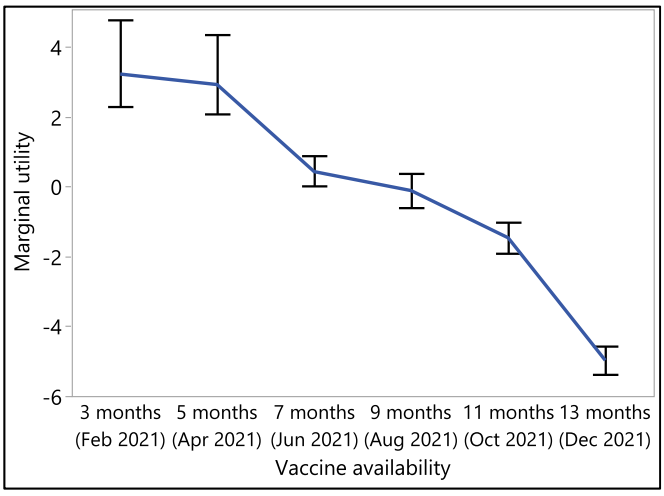

Fig. 2. Categorical PML marginal utility estimates of the vaccine availability attribute.

Looking at demographic subgroups (N = 791, excluding N = 3 reporting gender category "other", N = 99 providing no answer to whether they had been infected with COVID-19 and N = 2 providing no answer to the government's response to the COVID-19 pandemic), we observe that respondents who received the influenza vaccine last year found swift availability of a COVID-19 vaccine more important than those who did not (P < 0.0001). Men found it more important than women that the vaccine would be available sooner than later (P < 0.0001) and also gave more weight to mild side effects of the vaccine (P = 0.0017). Respondents who had likely not been infected with COVID-19 attached more value to the effectiveness of the vaccine than those who had likely been infected (P = 0.0006). Finally, respondents who thought the government's response to the pandemic was appropriate or insufficient urged more on rapid vaccine availability than those who believed the response was exaggerated (P = 0.0019). Table X.4 of Appendix 4 provides the detailed modelling results.

To predict the uptake of a COVID-19 vaccine in the adult population, we estimated two main opt-out models: an 'accept' model for direct acceptance of the vaccine against the choice to wait or refuse to take the vaccine (see Table 4a, left panel), and a 'wait' model for waiting to take the vaccine versus the choice to directly accept or refuse (see Table 4b). The 'accept' model shows that respondents who immediately accept the vaccine attach most importance to rapid availability and less to mild and serious side effects. Moreover, the effectiveness of the vaccine in this model was insignificant. Yet, when we removed all choices for vaccine refusal (i.e., 24%) from the data set and thus compared only to the waiting choices in the opt-out (see Table 4a, right panel), this attribute became highly significant. The 'wait' model shows that respondents who opted for waiting to take the vaccine attach most importance to mild side effects and vaccine effectiveness. Re-estimating the "wait" model ignoring all choices for direct vaccine acceptance (i.e., 27%) and so contrasting only with the vaccine refusal choices in the opt-out was not feasible due to a data separation problem in the HB estimation process (Kessels et al., 2019). Most probably, this is because about half of the respondents who refused the vaccine (i.e., 47% of N = 382), refused it in most of the choice sets, which may not have generated sufficient variation in the data. The positive opt-out coefficient in the 'accept' model and the insignificant opt-out coefficient in the 'wait' model can be explained by the fact that in almost half of the choices respondents preferred to wait some time before accepting the vaccine: of the 7160 choices made, 27% involved direct acceptance of the vaccine, 49% concerned the waiting strategy and 24% opted for vaccine refusal.

Extending the 'accept' model with a subgroup analysis (N = 892, excluding N = 3 reporting gender category "other") reveals that those who accept the COVID-19 vaccine largely correspond to people who received the influenza vaccine last year (P < 0.0001). They are also characterized by a higher level of education and a higher perceived risk of hospitalization after being infected with COVID-19 (both P < 0.0001). Furthermore, we observe that male respondents attach some utility to vaccine effectiveness as opposed to female respondents (P < 0.0001), even though the main effect of the effectiveness attribute remains insignificant, and older respondents found swift availability of the vaccine more important than younger respondents (P < 0.0001). Table X.5 of Appendix 4 provides the extended 'accept' model.

Enlarging the 'wait' model with a subgroup analysis (N = 893, excluding N = 2 providing no answer to the government's response to the COVID-19 pandemic) – see Table X.6 of Appendix 4 for the modelling results – shows that respondents who prefer to wait to take the vaccine are lower educated, believe that the government's response to the pandemic has been appropriate or insufficient and have a higher perceived risk of hospitalization after being infected with COVID-19 (both P < 0.0001). Furthermore, we observe that older respondents tend to be less hesitant to take the vaccine when the effectiveness is higher (P < 0.0001). Respondents were equally prone to selecting the "wait-and-see" option after selecting choice options with a short waiting time (e.g. 3 months or 5 months) and choice options with a long waiting time (e.g. 11 months or 13 months).

The opt-out model estimates (i.e., the means in Table 4a, left panel, and 4b) regarding people's preferences for (the attributes of) a COVID-19 vaccine can be used to predict uptake levels in the adult population for vaccines with different characteristics. Table 5 shows uptake levels for four vaccines that were included in the DCE. For an effective vaccine with severe side effects in 1 in 500 (Vaccine A), only 13% would take the vaccine immediately, 40% would wait and 47% would reject it. For an effective vaccine with few side effects (Vaccine C), 34% of the respondents would take it immediately, while 50% would wait and 16% would reject it. The best possible combination of vaccine attribute levels (Vaccine E: highest effectiveness, lowest side effects and earliest availability) would result in 39% accepting it immediately, 48% waiting and 13% refusing it.

The 637 participants who indicated they preferred to wait and take the vaccine later at least once in the eight choice situations were asked to indicate how long they were willing to wait to learn from the experiences of others. Of them, 41% wanted to wait between 1 and 3 months, 38% between 4 and 6 months, 13% between 7 and 12 months and 8% wanted to wait longer than a year.

Table 4a
Opt-out PML model estimates for predicting the share of respondents who will directly take the vaccine (ACCEPT model vs. wait or refuse) and for distinguishing these respondents from those who want to wait for experiences from others (ACCEPT model vs. wait): mean, standard deviation (SD), 95% credible interval and significance of the attribute effects obtained from likelihood ratio (LR) tests.

	ACCEPT model (vs. wait or refuse) (N = 895)			ACCEPT model (vs. wait) (N = 768)		
Model term	Mean (SD; subject SD)	95% credible interval	LR Chi-square	Mean (SD; subject SD)	95% credible interval	LR Chi-square
Increase of the effectiveness of the vaccine with 1%	NS			0.0225 (0.0076; 0.0921)	[0.0080; 0.0372]	94.132
Availability of the vaccine is delayed one month	−0.1870 (0.0195; 0.1194)	[−0.2236; −0.1477]	96.880	−0.3523 (0.0285; 0.2417)	[−0.4135; −0.2968]	156.801
Increase of cases of mild side effects (such as headache, painful arm and slight fever) per 1 out of 1000 vaccinations	−0.0404 (0.0021; 0.0298)	[−0.0449; −0.0367]	36.879	−0.0303 (0.0018; 0.0241)	[−0.0339; −0.0266]	56.834
Increase of cases of severe side effects requiring hospitalization (such as allergic reaction or inflammation of the blood vessels) per 1 out of 1000 vaccinations	−0.9215 (0.1079; 0.4376)	[−1.1335; −0.7206]	42.983	−1.8394 (0.1783; 0.9377)	[−2.1974; −1.5032]	71.237
Opt-out	1.0986 (0.2155; 3.6502)	[0.7100; 1.5391]	162.532	3.7249 (0.5208; 6.6466)	[2.7483; 4.7758]	130.138

Note: NS means non-significant at $P < 0.05$. All significant model terms are significant at $P < 0.0001$.

Table 4b
Opt-out PML model estimates for predicting the share of respondents who want to wait with the vaccine for experiences from others (WAIT model vs. accept or refuse): mean, standard deviation (SD), 95% credible interval and significance of the attribute effects obtained from likelihood ratio (LR) tests.

	WAIT model (vs. accept or refuse) (N = 895)		
Model term	Mean (SD; subject SD)	95% credible interval	LR Chi-square
Increase of the effectiveness of the vaccine with 1%	0.0116 (0.0038; 0.0651)	[0.0039; 0.0191]	85.016
Availability of the vaccine is delayed one month	−0.1428 (0.0134; 0.1323)	[−0.1671; −0.1166]	67.647
Increase of cases of mild side effects (such as headache, painful arm and slight fever) per 1 out of 1000 vaccinations	−0.0150 (0.0008; 0.0178)	[−0.0166; −0.0135]	89.422
Increase of cases of severe side effects requiring hospitalization (such as allergic reaction or inflammation of the blood vessels) per 1 out of 1000 vaccinations	−1.2360 (0.0876; 1.1550)	[−1.4073; −1.0698]	74.153
Opt-out	NS		

Note: NS means non-significant at $P < 0.05$. All significant model terms are significant at $P < 0.0001$.

4. Conclusions and discussion

Early November 2020, 87% of the respondents in this study was willing to take a COVID-19 vaccine, but 55% of them indicated they did not want to take the vaccine as soon as it becomes available, but rather wanted to wait for experiences of others. Specifically, we estimated that even with an optimal vaccine that is highly effective and has few side effects, only 39% of respondents would immediately accept the vaccine, whereas 48% would like to wait, and 13% would still refuse to be vaccinated. The willingness to vaccinate is considerably lower when a vaccine is less effective or when severe side effects occur more often. In that case, a large majority of respondents either wants to wait, or would refuse the vaccine altogether. On the other hand, our results show that respondents have a strong preference for vaccine immediacy, expressed as months until a vaccine is available and this particularly holds for older respondents, males and respondents who have received the influenza vaccine last year. Overall, respondents find it important that a safe and effective COVID-19 vaccine becomes available as soon as possible, but the majority do not want to be the first in line but rather prefers to wait a few months until experiences of others are known.

Our DCE adds to previous vaccination preference studies by offering respondents the option to postpone their decision to accept a COVID-19 vaccine. Hence, our predicted uptake rates are conditional on having this possibility in a vaccination programme and possibly are less useful in a context where individuals have to choose between accepting or rejecting a vaccine when it is offered or where not directly accepting the vaccine implies that you move to the end of the line and only will be

Table 5
Uptake estimates for vaccines with different combinations of attribute levels.

	Vaccine A	Vaccine B	Vaccine C	Vaccine D	Vaccine E[a]
Decrease in the number of people becoming ill from the coronavirus among people who have received the vaccine	90%	50%	80%	90%	90%
When will the vaccine be available for Dutch people?	5 months	5 months	3 months	7 months	3 months
Number of cases of mild side effects (such as headache, painful arm and slight fever) per 1,000,000 vaccinations	700,000 out of 1,000,000 (**70%**)	100,000 out of 1,000,000 (**10%**)	10,000 out of 1,000,000 (**1%**)	10,000 out of 1,000,000 (**1%**)	10,000 out of 1,000,000 (**1%**)
Number of cases of serious adverse reactions requiring hospitalization (such as allergic reaction or inflammation of the blood vessels) per 1,000,000 vaccinations	2000 out of 1,000,000 (**0.2%**)	5 out of 1,000,000 (**0.0005%**)	25 out of 1,000,000 (**0.0025%**)	100 out of 1,000,000 (**0.01%**)	5 out of 1,000,000 (**0.0005%**)
Percentage of Dutch people directly taking the vaccine	13%	17%	34%	30%	39%
Percentage of Dutch people who want to take the vaccine, but would like to wait a few months and first look at the experiences of others	40%	46%	50%	52%	48%
Percentage of Dutch people that will not take the vaccine	47%	37%	16%	18%	13%

[a] Vaccine E was based on model estimates using the best levels for each of the attributes. It was not part of the DCE vaccine options presented.

offered the vaccine again when the rest of the population has had a chance to get it. Our predicted uptake rates are also conditional on the assumption in our DCE that people who take the vaccine can freely travel, whereas people who do not take the vaccine would not be allowed to travel to countries with many COVID-19 infections or be required to go into quarantine when arriving and upon return. Hence, the uptake predictions might be overestimations when (foreign) governments would decide to allow people who are not vaccinated and people who are vaccinated to travel under the same conditions. On the other hand, our uptake predictions might underestimate the share of adult citizens who accept the vaccine when people who take the vaccine experience additional benefits compared with citizens who refuse the vaccine on top of being allowed to travel freely. In general, caution should be exercised when comparing the uptake levels from our study with those from other studies. However, when we compare the share of participants that accepts a safe and effective vaccine immediately or after a waiting period with other preference elicitation studies for a COVID-19 vaccine, we see a close resemblance: 87% in our study; 86% in (Borriello et al., 2021); 91% in (García and Cerda, 2020); 85% in (Leng et al., 2021); and 80% in (Dong et al., 2020). The uptake also matches the outcomes of a study of (Determann et al., 2014) who found that 88% of their sample would accept a vaccine in a (hypothetical) severe pandemic outbreak. Moreover, our finding that older people were more likely to accept a COVID-19 vaccine matches the results of (Borriello et al., 2021) and (Lazarus et al., 2021). In addition, our results line up with previous studies (Chor et al., 2011; Seale et al., 2010; Caserotti et al., 2021) which establish that individuals who received a vaccine against seasonal flu are more likely to accept a vaccine for a new pandemic disease. Our study also finds that respondents are prepared to wait an additional month for a vaccine to become available if that results in an increase in vaccine effectiveness of 3.3% or reduces the occurrence of mild and severe side effects with 43,111 and 147 per 1,000,000 vaccinations, respectively. The respondents in our study have a lower willingness to trade an additional month until the vaccine is available to increase effectiveness or to reduce severe side effects compared to the respondents in (Borriello et al., 2021) who were willing to wait an additional month for 1.5% increase in effectiveness or a reduction of severe side effects for 109 per 1,000,000 vaccinations.

A limitation of our study is that it was conducted at a time when there still was much uncertainty regarding the effectiveness and side effects of potential COVID-19 vaccines. The extent to which the results of our study can be generalized to vaccine preferences at a time when citizens are fully informed about the effectiveness and potential side effects of COVID-19 vaccines is therefore uncertain. Moreover, several changes in circumstances, such as the release of promising information on the effectiveness and limited side effects of the different vaccines that have been approved so far, the persistent severity of the pandemic, as well as the fear for the emergence of new strains of the coronavirus may have changed citizens' vaccination preferences. For instance, Sarasty et al. (2020) provide indicative evidence that vaccination uptake might be higher during a peak in a pandemic showing that a large proportion (97%) of individuals in Ecuador was willing to accept a vaccine in a period in time when 400 people died from COVID-19 per day. Moreover, Caserotti et al. (2021) found that hesitancy for a COVID-19 vaccine decreased during the first lockdown in Italy. On the other hand, in a number of EU countries, vaccination with AstraZeneca has been halted due to, likely causal, associations between the vaccine and thrombosis. This apparent rare but severe side effect may have resulted in several deaths across Europe. Such circumstances are likely to affect the willingness to vaccinate with these particular vaccines and may also affect the uptake of other vaccines for which these side effects have not been reported. Generally, we urge readers to consider the specific conditions under which this study was conducted when drawing conclusions from its findings. Future research may benefit from re-administrating vaccine preference studies at several phases of the pandemic, providing policy makers with useful information regarding possible changes in preferences, and underlying motives, as a pandemic progresses (Dong et al., 2020). Another limitation of our research is that we investigated how COVID-19 vaccine preferences are influenced by socio-demographic characteristics, acceptance of the annual influenza vaccination perceived risk of hospitalization or dying after being infected with COVID-19, but we did not study how COVID-19 vaccine preferences are affected by other relevant factors such as political partisanship and engagement with the political system (Ward et al., 2021), social norms (Latkin et al., 2021) and belief in anti-vaccine conspiracy theories (Milosevic Dordevic et al., 2021). A methodological limitation of our study is that we did not repeat one of the early choice situations at the end as a quality control check to identify respondents who gave invalid answers. Also, we did not offer special devices or personal assistance to respondents to complete the survey. In general, predicted uptake levels in our study are based on stated preferences, which might differ from people's real-world decisions about taking a COVID-19 vaccine due to design characteristics of the choice tasks that do not match the real-world choice situation. However, a recent study showed that 93% of individuals' real-world choices to opt for influenza vaccination were correctly predicted at the individual level in a DCE (de Bekker-Grob et al., 2019). We expect this may also be the case in this study on uptake of COVID-19 vaccination as our finding that 87% of the respondents in this study was willing to take a COVID-19 vaccine closely matches the vaccination rate of Dutch adults one year after we conducted our study being 87.2% (Corona Das, 2021). Another limitation of our study is that we were only able to discern the preferences and characteristics of respondents who prefer to wait by analysing the choice to wait against the choice to directly accept or refuse the vaccine and by comparing the waiting choices with the accept choices, but we were not able to discern the preferences and characteristics of respondents who prefer to wait from respondents who refuse the vaccine. Taking people's vaccination preferences into account when deciding on vaccination prioritization may help increase vaccine uptake and decrease delays in vaccination roll-out. This may especially prove beneficial in pandemic situations where vaccine production and delivery face capacity limitations and making optimal use of every available vaccine dose is of vital importance. Our study shows that a large share of the respondents was hesitant to take the COVID-19 vaccine directly and preferred to wait a few months to learn from the experiences of others. Because in most countries vaccine supply will be limited at the start of vaccination programmes, priority lists have been created and most people will have to wait to be vaccinated regardless of their preference, except for those groups who will be offered the vaccine first, such as the elderly and other groups with high medical risk. This policy aligns well with our results, which show that the willingness to directly accept the vaccine is relatively high among elderly and high-risk groups. Regardless, even among these groups, there is a considerable group that prefers to wait, especially for better information about effectiveness and side effects. We recommend to offer these people, and others who may be hesitant to accept the invitation to vaccinate immediately, a clear prospect of when and how they would be able to get vaccinated at a later moment. Will they have to join the back of the queue? Will they be invited again periodically? Or are they allowed to step in whenever they are ready for vaccination? Convincing the considerable group of individuals that want to delay their decision to actually take the vaccine seems vital for reaching the end goal of herd immunity. Our study shows that the group that prefers to wait to take the vaccine tends to be lower educated and that older people in this group are less inclined to wait when a vaccine is more effective than younger people. Hence, our results further suggest that vaccination campaigns targeted at older citizens should focus on the effectiveness of the vaccine. Our finding that men give more weight to mild side effects (e.g. headache, non-serious fever) of a vaccine than women may urge policy makers to target communication campaigns on that topic particularly toward men. Finally, we hope that the results of our study provide valuable insights for policy makers who need to decide during future pandemics about providing

people the option to delay their decision on the acceptance of a vaccine.

Author contributions

Dr. Niek Mouter: Conceptualization, Methodology, Acquisition of data, Supervision, Interpretation, Drafting of the manuscript. Annamarie de Ruijter: Methodology, Analysis and interpretation, Drafting of the manuscript. Dr. Ardine de Wit: Conceptualization, Methodology, Interpretation, Drafting of the manuscript. Dr. Mattijs S Lambooij: Conceptualization, Methodology, Interpretation, Drafting of the manuscript. Dr. Maarten van Wijhe: Conceptualization, Methodology, Interpretation, Drafting of the manuscript. Prof. Dr. Job van Exel: Conceptualization, Methodology, Interpretation, Drafting of the manuscript. Dr. Roselinde Kessels: Conceptualization, Methodology, Analysis and interpretation, Drafting of the manuscript, Data curation.

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Table X.1
Bayesian D-efficient design of 4 surveys.

Survey - Choice set	Percentage protected	Vaccine availability	Mild side effects	Severe side effects
1–1	80%	11 months	350,000	5
1–1	90%	7 months	200,000	25
1–2	50%	11 months	500,000	25
1–2	70%	3 months	10,000	1000
1–3	90%	5 months	700,000	2000
1–3	60%	13 months	10,000	25
1–4	80%	5 months	350,000	1000
1–4	60%	3 months	700,000	5
1–5	70%	13 months	100,000	500
1–5	80%	11 months	500,000	50
1–6	50%	5 months	10,000	50
1–6	80%	13 months	50,000	1000
1–7	90%	9 months	350,000	500
1–7	80%	7 months	20,000	100
1–8	50%	11 months	20,000	500
1–8	60%	7 months	500,000	2000
2–1	70%	9 months	50,000	100
2–1	90%	13 months	100,000	50
2–2	50%	13 months	500,000	1000
2–2	60%	11 months	350,000	100
2–3	70%	9 months	500,000	5
2–3	80%	13 months	700,000	100
2–4	60%	9 months	10,000	10
2–4	70%	3 months	350,000	25
2–5	80%	9 months	200,000	2000
2–5	70%	5 months	500,000	50
2–6	50%	9 months	50,000	50
2–6	60%	11 months	20,000	1000
2–7	60%	7 months	200,000	500
2–7	90%	13 months	50,000	10
2–8	80%	5 months	20,000	500
2–8	90%	11 months	700,000	1000
3–1	90%	13 months	20,000	2000
3–1	50%	3 months	100,000	1000
3–2	80%	3 months	10,000	25
3–2	70%	7 months	100,000	100
3–3	50%	3 months	20,000	2000
3–3	70%	11 months	200,000	10
3–4	60%	5 months	200,000	50
3–4	50%	7 months	350,000	10
3–5	70%	5 months	700,000	25
3–5	90%	11 months	100,000	500
3–6	70%	13 months	10,000	5
3–6	60%	3 months	20,000	10
3–7	60%	7 months	50,000	50
3–7	90%	13 months	500,000	100
3–8	60%	5 months	50,000	500
3–8	70%	9 months	20,000	50
4–1	80%	3 months	100,000	2000
4–1	90%	9 months	20,000	1000
4–2	50%	5 months	100,000	5
4–2	70%	3 months	500,000	500
4–3	80%	7 months	700,000	500
4–3	50%	3 months	200,000	100
4–4	80%	9 months	700,000	100
4–4	70%	11 months	50,000	2000
4–5	80%	13 months	200,000	10
4–5	90%	7 months	10,000	100
4–6	80%	11 months	100,000	25
4–6	60%	13 months	350,000	50
4–7	60%	9 months	100,000	25
4–7	50%	7 months	200,000	5
4–8	60%	7 months	350,000	5
4–8	70%	11 months	10,000	2000

(*continued on next column*)

Table X.1 (*continued*)

Survey - Choice set	Percentage protected	Vaccine availability	Mild side effects	Severe side effects
3–7	90%	13 months	500,000	100
3–8	60%	5 months	50,000	500
3–8	70%	9 months	20,000	50
4–1	80%	3 months	100,000	2000
4–1	90%	9 months	20,000	1000
4–2	50%	5 months	100,000	5
4–2	70%	3 months	500,000	500
4–3	80%	7 months	700,000	500
4–3	50%	3 months	200,000	100
4–4	80%	9 months	700,000	100
4–4	70%	11 months	50,000	2000
4–5	80%	13 months	200,000	10
4–5	90%	7 months	10,000	100
4–6	80%	11 months	100,000	25
4–6	60%	13 months	350,000	50
4–7	60%	9 months	100,000	25
4–7	50%	7 months	200,000	5
4–8	60%	7 months	350,000	5
4–8	70%	11 months	10,000	2000

Table X.2
Socio-demographic characteristics.

Characteristics	Percentage
Gender	
Male	47.9%
Female	51.7%
Other	0.3%
Age	
18–24 years	8.9%
25–34 years	14.6%
35–44 years	14.9%
45–54 years	16.9%
55–64 years	19.2%
65–74 years	15.1%
75 years and older	10.4%
Education	
Primary education	3.5%
Lower secondary education/MBO1	35.1%
Higher secondary education/MBO2-4	30.9%
HBO/University Bachelor	17.4%
HBO/University Master	13.1%
Employment status	
Full-time working	32.1%
Part-time working	16.2%
Student	4.9%
Not working/looking for a job	5.6%
Retired	23.2%
Housewife/-husband	7.3%
Incapacitated	10.5%
Employment sector	
Health care	6.8%
Contact professions	4.0%
Hospitality	3.4%
Job that involves contact with other people	17.2%
None of these apply	68.5%
Living area	
Village	20.7%
Small city	15.5%
Average city	34.0%
Large city	29.3%

Table X.3
Health characteristics.

Characteristics	Percentage
Rate your health. Indicate how healthy you feel at the moment.	
0 - 2	1.9%
3 - 5	12.2%
6 - 8	70.9%
9 - 10	14.4%

(*continued on next page*)

Table X.3 (*continued*)

Characteristics	Percentage
Rate your happiness. Indicate how happy you feel at the moment.	
0 - 2	2.1%
3 - 5	13.4%
6 - 8	66.0%
9 - 10	18.4%
Have you been infected with COVID-19?	
Tested and positive	1.7%
Probably positive but not tested	5.4%
Probably negative but not tested	64.3%
Tested and negative	26.7%
Do not want to answer	1.9%
Received the influenza vaccine	
Yes	13.7%
No	47.4%
Not yet, but wish to	25.8%
How do you rate the risk of becoming infected with COVID-19?	
No risk	3.9%
Low risk	40.8%
Reasonable risk	42.7%
High risk	11.1%
Extremely high risk	1.5%
How do you rate the risk of becoming ill after being infected with COVID-19?	
No risk	3.3%
Low risk	28.4%
Reasonable risk	41.2%
High risk	22.2%
Extremely high risk	4.9%
How do you rate the risk of hospitalization after being infected with COVID-19?	
No risk	7.9%
Low risk	42.3%
Reasonable risk	29.5%
High risk	15.5%
Extremely high risk	4.9%
How do you rate the risk of dying after being infected with COVID-19?	
No risk	13.7%
Low risk	47.4%
Reasonable risk	25.8%
High risk	10.6%
Extremely high risk	2.6%

Table X.4
PML model estimates with covariate effects for the full sample: mean, standard deviation (SD), 95% credible interval and significance of the attribute effects obtained from likelihood ratio (LR) tests.

Model term	Mean estimate (SD; subject SD)	95% credible interval	LR Chi-square	P-value
Increase of the effectiveness of the vaccine with 1%	0.1273 (0.0186; 0.1304)	[0.0916; 0.1623]	65.812	<.0001
Availability of the vaccine is delayed one month	−0.5732 (0.0464; 0.1697)	[−0.6682; −0.4964]	177.692	<.0001
Increase of cases of mild side effects (such as headache, painful arm and slight fever) per 1 out of 1000 vaccinations	−0.0155 (0.0013; 0.0218)	[−0.0180; −0.0129]	333.241	<.0001
Increase of cases of severe side effects requiring hospitalization (such as allergic reaction or inflammation of the blood vessels) per 1 out of 1000 vaccinations	−4.3456 (0.2551; 5.6161)	[−4.8603; −3.8400]	368.312	<.0001
Availability of the vaccine is delayed one month * Received the influenza vaccine				
[Yes]	−0.2636 (0.0778; 0.2006)	[−0.4585; −0.1373]	32.495	<.0001
[No]	0.1497 (0.0556; 0.1452)	[0.0407; 0.2482]		
[Not yet, but wish to]	0.1138 (0.0949; 0.1876)	[−0.0760; 0.2970]		
Availability of the vaccine is delayed one month * Gender				
[Male]	−0.1524 (0.0401; 0.1500)	[−0.2328; −0.0729]	17.126	<.0001
[Female]	0.1524 (0.0401; 0.1500)	[0.0729; 0.2328]		
Increase of the effectiveness of the vaccine with 1% * Infected with COVID-19				
[(Probably) positive]	−0.0643 (0.0203; 0.1096)	[−0.1033; −0.0250]	11.809	0.0006
[(Probably) negative]	0.0643 (0.0203; 0.1096)	[0.0250; 0.1033]		
Increase of cases of mild side effects per 1 out of 1000 vaccinations * Gender				
[Male]	−0.0027 (0.0014; 0.0223)	[−0.0055; −0.0000]	9.816	0.0017
[Female]	0.0027 (0.0014; 0.0223)	[0.0000; 0.0055]		
Availability of the vaccine is delayed one month * Govt's response to COVID-19				
[Insufficient]	−0.1315 (0.0568; 0.1535)	[−0.2487; −0.0248]	12.481	0.0019
[Appropriate]	−0.1992 (0.0524; 0.1576)	[−0.3040; −0.0981]		
[Exaggerated]	0.3307 (0.0762; 0.1803)	[0.2103; 0.5123]		

Table X.5
Opt-out PML model estimates with covariate effects for describing the respondents who will directly take the vaccine (ACCEPT model): mean, standard deviation (SD), 95% credible interval and significance of the attribute effects obtained from likelihood ratio (LR) tests.

Model term	Mean estimate (SD; subject SD)	95% credible interval	LR Chi-square	P-value
Increase of the effectiveness of the vaccine with 1%	−0.0050 (0.0080; 0.0707)	[−0.0203; 0.0101]	1.554	0.2125
Availability of the vaccine is delayed one month	−0.4128 (0.0283; 0.0882)	[−0.4665; −0.3580]	162.503	<.0001
Increase of cases of mild side effects (such as		[−0.0350; −0.0273]	61.146	<.0001

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Table X.5 (*continued*)

Model term	Mean estimate (SD; subject SD)	95% credible interval	LR Chi-square	P-value
headache, painful arm and slight fever) per 1 out of 1000 vaccinations	−0.0311 (0.0020; 0.0219)			
Increase of cases of severe side effects requiring hospitalization (such as allergic reaction or inflammation of the blood vessels) per 1 out of 1000 vaccinations	−2.2117 (0.1771; 1.1261)	[−2.6158; −1.8798]	80.786	<.0001
Opt-out	5.4181 (0.8204; 6.4389)	[4.0662; 7.0046]	205.544	<.0001
Increase of the effectiveness of the vaccine with 1% * Gender				
[Male]	0.0454 (0.0062; 0.0738)	[0.0337; 0.0576]	58.220	<.0001
[Female]	−0.0454 (0.0062; 0.0738)	[−0.0576; −0.0337]		
Availability of the vaccine is delayed one month * Age				
[18–24 years]	0.2368 (0.0660; 0.0724)	[0.1085; 0.3757]	27.631	0.0001
[25–34 years]	0.2012 (0.0612; 0.0746)	[0.0752; 0.3183]		
[35–44 years]	0.0395 (0.0757; 0.0638)	[−0.0818; 0.1936]		
[45–54 years]	−0.0421 (0.0595; 0.0780)	[−0.1536; 0.0714]		
[55–64 years]	−0.0868 (0.0912; 0.0791)	[−0.2432; 0.0818]		
[65–74 years]	−0.1182 (0.0761; 0.1042)	[−0.2537; 0.0255]		
[75 years and older]	−0.2305 (0.0794; 0.0645)	[−0.3774; −0.0836]		
Opt-out * Received the influenza vaccine				
[Yes]	−3.0099 (0.6625; 0.1897)	[−4.0922; −1.8740]	368.288	<.0001
[No]	4.9693 (0.5755; 0.9199)	[3.9153; 6.2270]		
[Not yet, but wish to]	−1.9594 (0.8734; 0.3462)	[−3.5752; −0.3349]		
Opt-out * Education				
[Primary or lower secondary]	1.6267 (0.6625; 0.2589)	[0.0105; 2.5845]	67.842	<.0001
[Higher secondary]	−0.0555 (0.5632; 0.2954)	[−1.1763; 0.9019]		
[Higher professional or university]	−1.5711 (0.5341; 0.2861)	[−2.7486; −0.7018]		
Opt-out * Hospitalization risk				
[No risk]	0.4816 (1.1176; 1.0956)	[−1.5301; 2.6497]	45.445	<.0001
[Low risk]	0.2237 (0.5930; 1.1224)	[−0.9463; 1.3178]		
[Reasonable risk]	0.9597 (1.0500; 0.6225)	[−1.3214; 2.3985]		
[(Extremely) high risk]	−1.6650 (0.6995; 0.4765)	[−2.9366; −0.2572]		

(*continued on next column*)

Table X.5 (*continued*)

Model term	Mean estimate (SD; subject SD)	95% credible interval	LR Chi-square	P-value

Table X.6
Opt-out PML model estimates with covariate effects for describing the respondents who want to wait for experiences from others (WAIT model): mean, standard deviation (SD), 95% credible interval and significance of the attribute effects obtained from likelihood ratio (LR) tests.

Model term	Mean estimate (SD; subject SD)	95% credible interval	LR Chi-square	P-value
Increase of the effectiveness of the vaccine with 1%	−0.0213 (0.0049; 0.0516)	[−0.0312; −0.0007]	173.675	<.0001
Availability of the vaccine is delayed one month	−0.1668 (0.0149; 0.1693)	[−0.1959; −0.1397]	123.754	<.0001
Increase of cases of mild side effects (such as headache, painful arm and slight fever) per 1 out of 1000 vaccinations	−0.0136 (0.0008; 0.0165)	[−0.0153; −0.0119]	192.475	<.0001
Increase of cases of severe side effects requiring hospitalization (such as allergic reaction or inflammation of the blood vessels) per 1 out of 1000 vaccinations	−1.4951 (0.1023; 1.5243)	[−1.7050; −1.3340]	167.638	<.0001
Opt-out	0.5423 (0.3834; 3.6856)	[−0.1782; 0.9442]	1.815	0.1779
Increase of the effectiveness of the vaccine with 1% * Age				
[18–24 years]	0.0598 (0.0169; 0.0436)	[0.0260; 0.0912]	70.754	<.0001
[25–34 years]	0.0684 (0.0157; 0.0462)	[0.0398; 0.0836]		
[35–44 years]	0.0198 (0.0134; 0.0428)	[−0.0056; 0.0181]		
[45–54 years]	0.0076 (0.0146; 0.0446)	[−0.0199; 0.0060]		
[55–64 years]	0.0016 (0.0166; 0.0481)	[−0.0321; 0.0315]		
[65–74 years]	−0.0031 (0.0124; 0.0416)	[−0.0292; 0.0214]		
[75 years and older]	−0.1541 (0.0119; 0.0403)	[−0.1779; −0.1315]		
Opt-out * Education				
[Primary or lower secondary]	−1.4679 (0.5176; 0.6852)	[−2.5256; −0.9126]	78.564	<.0001

(*continued on next page*)

Table X.6 (*continued*)

Model term	Mean estimate (SD; subject SD)	95% credible interval	LR Chi-square	P-value
[Higher secondary]	−0.4684 (0.3761; 0.5044)	[−1.2662; 0.4405]		
[Higher professional or university]	1.9363 (0.4653; 0.5647)	[1.0057; 2.8157]		
Opt-out * Govt's response to COVID-19				
[Insufficient]	−0.3433 (0.4933; 0.1351)	[−1.1530; 0.5192]	40.675	<.0001
[Appropriate]	−1.2613 (0.3899; 0.1700)	[−2.0411; −0.5245]		
[Exaggerated]	1.6046 (0.3199; 0.2840)	[1.0186; 2.8462]		
Opt-out * Hospitalization risk				
[No risk]	3.2417 (0.4637; 0.2638)	[2.3143; 4.1135]	36.565	<.0001
[Low risk]	−0.4701 (0.3442; 0.1765)	[−1.1982; 0.0905]		
[Reasonable risk]	−1.2439 (0.5285; 0.2120)	[−2.3008; −0.2504]		
[(Extremely) high risk]	−1.5278 (0.4991; 0.2234)	[−2.5259; −0.5895]		

Declaration of competing interest

The authors have nothing to disclose.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2021.114626.

Appendix

Appendix 1. Selection of attributes and levels

The initial selection of the attributes was based on characteristics of (COVID-19) vaccines that were included in comparable studies on consumer preferences of a (COVID-19) vaccine (Craig, 2021; Veldwijk et al., 2014). To identify the most relevant attributes for policy makers, we discussed potential attributes arising from this literature with policymakers from the Ministry of Health. From this discussion, we selected six policy-relevant attributes: 1) Percentage of vaccinated individuals that are protected against the coronavirus; 2) Month in which vulnerable groups can get the vaccine; 3) Month in which people who do not belong to the vulnerable groups can get the vaccine; 4) Duration of protection by the vaccine; 5) Number of cases of mild side effects; 6) Number of cases of severe side effects. We sent a draft version of the experiment containing our selection of attributes and levels to eight experts (including epidemiologists, physician-microbiologists and experts from the Pharmacovigilance Centre Lareb, the national organization that monitors adverse drug reactions) for evaluation of the attributes and levels. We asked them to verify whether we overlooked relevant attributes and check the validity of the attribute levels. These experts provided valuable feedback on the range for the attribute levels. We incorporated this feedback and made a draft version of the DCE which was tested in a pilot study with a convenience sample of 50 respondents. The feedback from the pilot study resulted in two changes. First, we decided to no longer make a distinction between availability for vulnerable groups and the rest of the population. From the explanations of their choices, we observed that participants in the pilot study who did not belong to the vulnerable group interpreted the experiment incorrectly. Many of them were inclined to give advice on which vaccine they thought was best from a societal perspective (thus attributing value to availability for vulnerable groups) while we asked them which vaccine they *themselves* would choose. Secondly, we decided not to include the attribute about the time period during which the vaccine offers protection as this attribute raised confusion among respondents about the safety and effectiveness attributes regarding the first time the vaccine was taken and the potential second time, if the first vaccine no longer offered protection. Thus, a DCE containing 4 attributes remained, shown in Table 1 of the main paper.

Appendix 2. Bayesian D-efficient design of 4 surveys for the discrete choice experiment

The design of the DCE involved four surveys of 8 choice sets with two vaccine profiles. The choice tasks appear in Table X.1. Each survey was conducted by about 225 respondents. The choice sets are described by four attributes whose levels are varied. The design is Bayesian D-efficient for the precise estimation of the four attribute effects and has a Bayesian D-criterion value of 28.30 (Kessels et al., 2011). The underlying design generating model is the multinomial logit (MNL) model, but the design also performs well for the precise estimation of the panel mixed logit model since the latter assumes MNL models for all individuals over which it averages. We generated the design using the coordinate-exchange algorithm in the JMP Pro 16 software.

Appendix 3. Background characteristics of participants

Table X.2 shows the socio-demographic characteristics of the respondents and Table X.3 shows their health characteristics and risk perceptions.

Appendix 4. Model results including respondent characteristics

To derive the marginal utility that respondents with certain characteristics obtain from the attributes of the COVID-19 vaccine, we estimated PML models with a linear-in-the-parameters utility function using the Hierarchical Bayes technique in the JMP Pro 16 Choice platform. First, we analysed the forced choice data. The modelling results accounting for respondent covariates are presented in Table X.4.

Second, we analysed the opt-out data from the follow-up question of the choice situations where respondents were asked whether or not they would accept, wait or refuse to take the vaccine they had primarily selected in the forced choice task. The modelling results including respondent covariates are presented in Tables X.5 and X.6.

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