Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Efficacy or delivery? An online Discrete Choice Experiment to explore preferences for COVID-19 vaccines in the UK

Robert McPhedran*, Ben Toombs
Kantar Public UK Behavioural Practice, 4 Millbank, London, SW1P 3JA, United Kingdom

A R T I C L E   I N F O
Article history:
Received 6 November 2020
Received in revised form 12 January 2021
Accepted 14 January 2021
Available online 29 January 2021

Keywords:
Discrete Choice Experiment
COVID-19
Vaccination

A B S T R A C T
COVID-19 vaccines are widely regarded as an integral component in the UK’s pandemic recovery, and a comprehensive distribution strategy will be required to maximise uptake. However, to date, there is a dearth of research into factors that could lead to UK residents’ acceptance or rejection of COVID-19 vaccines.

This study used a discrete choice experiment to investigate the importance of vaccine properties, delivery and media coverage in amplifying or attenuating vaccine uptake. Efficacy was found to be the factor that most influenced vaccine selection; further, the positive effect of high efficacy was more pronounced for those aged 55+.

Insights from this DCE aim to assist policymakers and public health communicators in planning and refining their delivery strategy for COVID-19 vaccines.

© 2021 The Author(s). Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

1. Introduction

The COVID-19 pandemic has had an immensely deleterious effect on the United Kingdom (UK). At the time of writing, there have been more than 1,000,000 positive cases and over 80,000 people have died within 28 days of a positive COVID-19 test (Gov.uk, 2021).

Widespread uptake of an efficacious vaccine will be a key facilitator of the UK’s adaptation to, and ultimately recovery from, the pandemic (Peiris and Leung, 2020). Evidence of how UK residents will respond to different COVID-19 vaccine options is therefore now needed to optimise delivery.

Several recent studies have asked UK residents directly about their behavioural intentions regarding COVID-19 vaccination. Limitations of this approach have been well documented, including the susceptibility of survey responses to social desirability bias (Malik et al., 2020). More generally, Faries (2016) demonstrated that stated intention only predicts 30%-40% of the variance in health behaviour.

Discrete choice experiments (DCEs), however, have been shown to be a robust method for predicting behaviours and preferences across a range of economics fields. They have been widely used in health economics to analyse trade-offs between patient experience and outcomes, health professionals’ treatment preferences and other applications (Clark et al., 2014); further, they have accurately predicted positive vaccination behaviour at a rate exceeding 80% (Lambooij et al., 2015).

However, DCEs have rarely been used in a rapidly evolving environment where the impacts of the situation are universal and the need for action is urgent, such as the COVID-19 pandemic. To date, there has not been a DCE involving a representative sample of UK residents which explicitly aims to enhance the design and implementation of the UK’s COVID-19 vaccination programme.

This paper therefore not only provides robust evidence regarding population preferences for UK policy-makers; it demonstrates the practical value of applying an established tool for economic analysis in a live policy environment.

2. Methodology

2.1. Sample

This DCE was conducted online, involving n=1,501 participants from Kantar’s LifePoints panel. Fieldwork was conducted from 27 August - 3 September 2020, and the average completion time was 10.1 min.

Parallel quotas on key demographics – including age, gender and geographical region – were enforced (based on mid-year population estimates from the UK’s Office for National Statistics (2019)). As these quotas were precisely met in field (see Table 1), data were unweighted.

* Corresponding author.
E-mail address: robert.mcphedran@kantar.com (R. McPhedran).

https://doi.org/10.1016/j.econlet.2021.109747
0165-1765/© 2021 The Author(s). Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
2.2. Experiment design

One consequence of operating in a live policy environment was the need for rapid, responsive development of the DCE – drawing on the best evidence available to ensure that results could inform distribution strategy. As such, rather than conducting primary qualitative research to determine the DCE’s attributes and levels, selection was based on a review of similar vaccine DCEs, including those informed by focus groups (Determann et al., 2014, 2016; Dong et al., 2020).

As in other studies where secondary data were used for design (see Hoogink et al., 2020), the most influential attributes from the reference DCEs were chosen for inclusion; an additional UK COVID-19 programme-specific attribute – administration location – was also incorporated (see Table 2).

A full factorial design would have involved presenting 48 vaccine profiles (2^4 * 3^1), making implementation unfeasible in a short online survey. Therefore, a rotation design – developed from an orthogonal main-effects array – was generated using the Support.CE package in R statistical software (Aizaki, 2015). A design with a relatively small number of blocks (two) minimised the possibility of imbalance between blocks following administration (Hensher et al., 2015).

The final design comprised 12 paired scenarios, across two blocks of 6 pairs. In each pair, an opt-out (neither vaccine) option was presented to maximise external validity. As recommended in the literature, D–efficiency was compared against a competing design (Mangham et al., 2008).

An example paired choice scenario can be seen in Fig. 1.

2.3. Data analysis

A clustered conditional logit model – run via the Survival package in R statistical software (Therneau, 2015) – was used in analysis. Selection of a COVID-19 vaccine based on its attributes – the main effects model – is written as:

\[ V_{im} = \alpha + \beta_1 \text{Eff}50 + \beta_2 \text{Eff}90 + \beta_3 \text{NHS} + \beta_4 \text{GovSoc} + \beta_5 \text{VacMob} + \beta_6 \text{Dose2} + \varepsilon_{im} \]

Where:

- \( V_{im} \) represents the ith vaccine chosen by participant n;
- \( \alpha \) represents the alternative specific constant (ASC), denoting likelihood of vaccine selection relative to the opt-out ‘status quo’ (specified using dummy coding);
- \( \beta_1-\beta_6 \) represent the effects of the vaccine attributes upon selection (specified using dummy coding); and
- \( \varepsilon_{im} \) represents the random error term (the non-observable component of choices).

In conditional regression models, one of the primary assumptions is the independence of irrelevant alternatives. The Hausman and McFadden (1984) test was used to verify that this assumption was met. A hybrid logit model examining the interaction between older age (55+ years) and DCE attributes was also run. This model (henceforth referred to as Model 2) was used to determine if the preferences of older residents – who are highly vulnerable to the virus (Yanez et al., 2020) – differ from those of the general population.

3. Results

3.1. Logit models

Results for the models can be seen in Table 3. The significant ASC (odds ratio = 4.12, p < 0.001) indicates a population-level preference for vaccine selection over ‘opting out’. Efficacy was by far the most influential characteristic in determining selection of COVID-19 vaccines, as evidenced by the high odds ratio of selection of a vaccine with 90% efficacy relative to a vaccine with 70% efficacy (odds ratio = 0.81, p < 0.001). Location of vaccine administration was also important: the local GP surgery was preferred over mobile vaccination units (odds ratio = 0.81, p < 0.001).

Similar but more pronounced results were observed for those aged 55+ years in Model 2. Specifically, highly significant interactions were observed with the ASC (odds ratio = 2.09, p < 0.001), efficacy (90% odds ratio = 1.44, p < 0.001) and recommender (NHS odds ratio = 0.92, p < 0.001).

3.2. Opt-outs

Fig. 2 illustrates the proportion of people who opted out of any of the pairs by selecting the ‘neither vaccine’ option. More than three quarters (77%) of participants selected one of the two vaccines in all six of the pairs; 7% opted out of all six of the pairs; and the remainder opted out at least once.

As would be expected given the interactions in Model 2, opt-out behaviour differed significantly according to age. Eighty-six percent of those aged 55+ selected a vaccine in all six scenarios, a proportion significantly higher than that observed for those aged 16–34 (65%; Z = 7.77, p < 0.001) and 35–54 (77% Z = 3.77, p < 0.001).

4. Discussion and conclusions

This is the first DCE in which the preferences of UK residents regarding COVID-19 vaccines are explored. The results underscore the importance of characteristics of both the vaccines and their distribution programmes in amplifying or attenuating...
Table 2

DCE attributes and levels.

| Attribute                          | Levels          |
|------------------------------------|-----------------|
| Level of protection offered        | 1 50%           |
|                                    | 2 70%           |
|                                    | 3 90%           |
| Recommender of the vaccine         | 1 GP            |
|                                    | 2 NHS           |
| Number of doses needed for full    | 1 One           |
| protection                         | 2 Two           |
| Location in which the vaccine is   | 1 Local GP surgery |
| administered                       | 2 Mobile vaccination unit |
| Coverage in the media              | 1 Positive coverage in newspapers, television and radio |
|                                    | 2 Positive coverage on WhatsApp, blogs and social media |

*Reference category.

The full DCE introduction is appended, please see Appendix.

uptake among UK residents. Positively, results highlight a population preference for vaccination against COVID-19 over the non-vaccination ‘status quo’; this preference was more pronounced among residents aged 55+.

This study also clearly demonstrates that efficacy levels of COVID-19 vaccines are central to their appeal: the odds that a vaccine with 90% efficacy was chosen were 2.80 times the odds that a vaccine with 70% efficacy was chosen. In Model 2, older age (55+) interacted significantly with efficacy level, indicating that high efficacy acts as an even greater inducement to older, more vulnerable residents.
### Table 3
Results of conditional logit main effect and age interaction models.

| Attribute                          | Levels                        | Coeff  | Odds ratio | SE (coeff) | Coeff  | Odds ratio | SE (coeff) |
|-----------------------------------|-------------------------------|--------|------------|------------|--------|------------|------------|
| ASC                               |                               | 1.42***| 4.12       | 0.05       | 1.19***| 3.27       | 0.06       |
| Level of protection offered       | 50%                           | -1.30***| 0.27       | 0.04       | -1.11***| 0.33       | 0.05       |
|                                   | 90%                           | 1.03***| 2.80       | 0.03       | 0.92***| 2.50       | 0.04       |
| Recommender of the vaccine        | NHS                           | -0.07** | 0.94       | 0.03       | -0.04***| 0.96       | 0.03       |
| Number of doses needed for full protection | Two                  | -0.15***| 0.86       | 0.03       | -0.17***| 0.85       | 0.03       |
| Location in which the vaccine is administered | Mobile vaccination unit | -0.21***| 0.81       | 0.03       | -0.17***| 0.84       | 0.03       |
| Coverage in the media             | Positive coverage on WhatsApp, blogs and social media | -0.17***| 0.83       | 0.03       | -0.15***| 0.86       | 0.03       |
| ASC * 55+                         |                               | 0.74***| 2.09       | 0.10       |
| Level of protection offered* 55+  |                               | -0.61***| 0.54       | 0.10       |
|                                  | 90% * 55+                     | 0.36***| 1.44       | 0.08       |
| Recommender of the vaccine * 55+  | NHS * 55+                     | -0.08***| 0.92       | 0.06       |
| Number of doses needed for full protection * 55+ | Two * 55+               | 0.07    | 1.07       | 0.06       |
| Location in which the vaccine is administered* 55+ | Mobile vaccination unit * 55+ | -0.12    | 0.89       | 0.06       |
| Coverage in the media * 55+       | Positive coverage on WhatsApp, blogs and social media * 55+ | -0.14*   | 0.87       | 0.06       |

*** = \( p < 0.001 \)

** = \( p < 0.01 \)

* = \( p < 0.05 \)

Viewed within the context of the UK distribution programme (Department of Health and Social Care, 2021), these results are encouraging. Two of the vaccines approved for use – the BioNTech/Pfizer (Polack et al., 2020) and Moderna vaccines (Baden et al., 2020) – possess efficacy rates exceeding 90%, suggesting that many residents will choose to receive them without further encouragement. However, given the programme also encompasses a vaccine with lower efficacy which will be more widely distributed – the Oxford/AstraZeneca vaccine (Voysey et al., 2020) – there may still be some reluctance. Consequently, distinct distributional, behavioural or communication strategies may be required to augment population-level uptake.

The results of this study are largely congruent with other recent vaccine DCEs. As observed elsewhere, in addition to efficacy, number of doses and source of recommendation are influential (see Dong et al., 2020; Kreps et al., 2020). However, in the present study, location of administration was included, with the expectation that the need for rapid and widespread distribution would likely result in a range of location types. This attribute was unique to this study, and proved to be the second most influential in determining vaccine selection, with local GP surgeries preferred over mobile centres. In practical terms, the result signifies that local vaccination services (such as in GP surgeries) will be favoured by many residents across the UK, rendering capacity a potential issue.

This study demonstrates that it is possible to expedite the design of a DCE to ensure results can inform strategy, by determining attributes prior to the detail of these features becoming clear. However, this approach limits the extent to which the effects of specific features of the vaccines and their delivery programmes can be analysed. Future DCEs and other research should therefore seek to build on this study’s results, examining take-up in greater depth. Follow-up work should also aim to increase understanding of the public’s knowledge and perceptions of vaccine and programme characteristics via primary quantitative and qualitative research.

Nonetheless, the present study provides clear evidence for the utility of DCEs in formulating vaccination programmes, and for their use in fast-changing environments. The results may assist UK policymakers and public health communicators in preparing and refining the COVID-19 vaccine delivery plan.

**Data sharing**

The raw data is accessible by contacting the corresponding author.

**Acknowledgements**

Thanks go to the team members from the Behavioural Practice, Kantar Public UK, for their contributions.

**Funding**

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
Appendix. DCE introduction

“There are various clinical trials underway in search for an effective vaccination against Covid-19.

In this online experiment, we would like you to imagine that there are a number of vaccines available to you. Every vaccine offered has passed human safety trials and will vary in terms of their characteristics.

On each screen in the next section, you will be presented with two different vaccines. In each case, please select the vaccine you would choose to have yourself, considering only the displayed characteristics. You can also select ‘No Vaccination’ if neither of the options on that page are acceptable to you’.

References

Aizaki, H., 2015. Package ‘support.CEs’. https://cran.rproject.org/web/packages/support.CEs/support.CEs.pdf.
Baden, L., et al., 2020. Efficacy and safety of the mRNA-1273 SARS-CoV-2 vaccine. N. Engl. J. Med. http://dx.doi.org/10.1056/NEJMoa2035389.
Clark, M., et al., 2014. Discrete choice experiments in health economics: A review of the literature. Pharmacoeconomics 32, 883–902. http://dx.doi.org/10.1007/s40273-014-0170-x.
Department of Health and Social Care, 2021. UK COVID-19 vaccines delivery plan. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/951284/UK_COVID-19_vaccines_delivery_plan.pdf.
Determann, D., et al., 2014. Acceptance of vaccinations in pandemic outbreaks: A discrete choice experiment. PLoS One 9 (7), http://dx.doi.org/10.1371/journal.pone.0102505.
Determann, D., et al., 2016. Public preferences for vaccination programmes during pandemics caused by pathogens transmitted through respiratory droplets – a discrete choice experiment in four European countries, 2013. Euro Surveillance 21 (22), 1–13. http://dx.doi.org/10.2807/15607917.ES.2016.21.22.30247.
Dong, D., et al., 2020. Public preference for COVID-19 vaccines in China: A discrete choice experiment. Health Expect. 1–36. http://dx.doi.org/10.1111/hex.13140.
Faries, M., 2016. Why we don’t just do it: Understanding the intention-behavior gap in lifestyle medicine. Am. J. Lifestyle Med. 10 (5), 322–329.
Gov.uk, 2021. Coronavirus (COVID-19) in the UK. https://coronavirus.data.gov.uk/cases. (Accessed 11/1/2021).
Hausman, J., McFadden, D., 1984. Specification tests for the multinomial logit model. Econometrica 52 (5), 1219–1240. http://dx.doi.org/10.2307/1910997.
Hensher, D., Rose, J., Greene, W., 2015. Applied Choice Analysis, second ed. Cambridge University Press, http://dx.doi.org/10.1017/CBO9781316136232.
Hoogink, J., et al., 2020. Preferential differences in vaccination decision-making for oneself or one’s child in The Netherlands: a discrete choice experiment. BMC Publ. Health 20 (828), http://dx.doi.org/10.1186/s12889-020-08844-w.
Kreps, S., et al., 2020. Factors associated with US adults’ likelihood of accepting COVID-19 vaccination. JAMA Netw Open 3 (10), http://dx.doi.org/10.1001/jamanetworkopen.2020.25594.
Lambooij, M., et al., 2015. Consistency between stated and revealed preferences: a discrete choice experiment and a behavioural experiment on vaccination behaviour compared. BMC Med. Res. Methodol. 15 (19), http://dx.doi.org/10.1186/s12874-015-0010-5.
Malik, A., et al., 2020. Determinants of COVID-19 vaccine acceptance in the US. eClinicalMedicine http://dx.doi.org/10.1016/j.eclinm.2020.100495.
Mangham, L., Hanson, K., McPake, B., 2008. How to do (or not to do)... Designing a discrete choice experiment for application in a low-income country. Health Policy Plan 24, 151–158. http://dx.doi.org/10.1093/heapol/czn047PMID:19112071.
Peirus, M., Leung, G., 2020. What can we expect from first-generation COVID-19 vaccines? Lancet http://dx.doi.org/10.1016/S0140-6736(20)31976-0.
Polack, F., et al., 2020. Safety and efficacy of the BNT162b2 mRNA Covid-19 vaccine. N. Engl. J. Med. 383, 2603–2615. http://dx.doi.org/10.1056/NEJMoa2035389.
Therneau, T., 2015. A package for survival analysis in R. https://cran.rproject.org/package=survival.
Voysey, M., et al., 2020. Safety and efficacy of the ChAdOx1 nCoV-19 vaccine (AZD1222) against SARS-CoV-2: an interim analysis of four randomised controlled trials in Brazil, South Africa, and the UK. Lancet 397, 99–111. http://dx.doi.org/10.1016/S0140-6736(20)32661-1.
Yanez, D., et al., 2020. COVID-19 mortality risk for older men and women. BMC Publ. Health 20, 1742. http://dx.doi.org/10.1186/s12889-020-09826-8.