Article

Individual Preferences for COVID-19 Vaccination under the China’s 2021 National Vaccination Policy: A Discrete Choice Experiment Study

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Abstract: (1) Background: Since China’s national vaccination policy announcement in January 2021, individual vaccination preferences related to vaccine characteristics, social relationships, sociodemographic characteristics and cognition remain opaque. This study aims to investigate vaccination preferences regarding these attributes, and to assess changes in individual vaccine preferences since the pre-2021 emergency vaccination phase. (2) Methods: The two-part questionnaire surveyed 849 individuals between May and June 2021 in Qingdao, China. The survey contained eight binary choice tasks that investigated preference trade-offs. Respondents’ sociodemographic characteristics, including age, sex, urban/rural residence, income, education and whether living with the young or old, were also collected. Conditional logit, mixed logit and latent class models were used to quantify preference utility and identify preference heterogeneity. (3) Results: Vaccine effectiveness, vaccine side effects, duration of protection and probability of infection all significantly affected vaccination utility. Preference heterogeneity based on individual social relationships and sociodemographic characteristics were also established. Marginal analysis showed that compared to the pre-2021 phase, individuals’ preferences had shifted towards vaccines with longer protection periods and better accessibility. (4) Conclusion: This study will inform the full rollout of China’s 2021 national vaccination program and provide valuable information for future vaccination policy design to meet resurgent COVID-19 risks.

Keywords: vaccination preference; COVID-19; post-2021 national vaccination policy; vaccination preference changes

1. Introduction

Between January 2020 and December 2021, there have been 2.8 billion confirmed global cases of COVID-19, with 5.4 million recorded deaths [1]. Since the initial Alpha outbreak, mutated variants (Delta and Omicron) have become the dominant strands of the virus and pose a growing global public health challenge [2,3]. Vaccination continues to be the most effective way to combat COVID-19 [4–7], with WHO reporting 8.6 billion doses of COVID-19 vaccines administered as of December 2021 [1]. Many countries have introduced booster doses to combat COVID-19 variants and prolong vaccine effectiveness [8,9]. For China, vaccination is the central focus for COVID-19 prevention. While China had administered 2.7 billion vaccine doses by December 2021 [10], further vaccinations are required for disease control, as COVID-19 is resurgent in China and abroad [11,12]. The Chinese
government set a two-dose vaccination target for 80% of the population by the end of 2021 [13], with booster doses implemented in many provinces to contain resurgent COVID-19 outbreaks [14].

Understanding individual vaccination preferences is vital to facilitate vaccine roll-outs and increase vaccine coverage. Previous vaccination studies have identified vaccine efficacy, safety, history and costs, social relationships, cognition (risk–benefit vaccine perceptions), trust in healthcare systems, openness to experience and sociodemographic characteristics as important factors influencing individual vaccine uptake [15–25]. Prior to the approval of the first Sinopharm vaccine in 2021 [26], Chinese public opinion surveys of vaccine acceptance rates ranged between 36.4% and 94.3% [21,27,28]. Studies found that vaccine hesitancy caused by misinformation, pre-existing medical conditions, mistrust towards medical institutions and governments, concerns for vaccine efficacy, fear of vaccine adverse effects and respondents’ sociodemographic characteristics were the main reasons behind vaccination reluctance [29–33]. Other studies identified healthcare workers, nurses, college students and parents with children under 18 as specific groups requiring targeted pro-vaccine communication to address vaccine hesitancy [16,31,34–46]. Health belief models related Chinese vaccine hesitancy to individual cognition factors, such as perceived benefits, perceived risks and perceived barriers [33,37]. During the pre-2020 study period, it was unclear whether China’s vaccinations would be free [38], and research has found that costs significantly affect individual willingness to vaccinate [15,22,38,39]. Studies investigating pre-2021 individual vaccination preference trade-offs found that vaccine efficacy, vaccine-related side effects, vaccination sites, duration of protection, access to vaccine, number of doses required and percentages of acquaintances vaccinated impacted individual vaccination preferences [40,41].

Since the above studies, China approved the Sinopharm vaccine in December 2020 and the Sinovac vaccine in February 2021, which account for the vaccines with the majority of the market share for general use [26,38,42,43]. Second, on 9 January 2021, the National Health Commission of China (NHS) decreed a national free and voluntary COVID-19 vaccination policy [44]. Under the 2021 national vaccination policy, free vaccination increased individuals’ willingness to uptake [45,46]. However, various studies have reported that vaccine hesitancy caused by misinformation, lack of trust, concerns regarding vaccine efficacy and safety, cognition and sociodemographic characteristics continued to deter vaccine uptake [47–54]. Under the 2021 national vaccination policy, discrete choice experiment (DCE) studies assessed individual vaccination preferences based on vaccine attributes, such as effectiveness, adverse effects, protection period and cost [55–58]. One constraint was that these studies were limited by the absence of variables on individuals’ social relationships and cognition in the vaccination decision. Additionally, there is a lack of knowledge on how individual vaccination attitudes might have changed between the pre-2021 and post-2021 national policy periods.

To address these lacunae, we undertook a DCE to assess individual vaccination preferences under China’s 2021 free national vaccination policy. Our study is one of the first to assess vaccination preferences under China’s national vaccination policy, considering not only vaccine characteristics, but social relationships and cognition, such as perception of risk. Social relations are an individual’s immediate relationships, defined in this study as the percentage of acquaintances vaccinated and living with children and the elderly. Our study also addresses how public acceptance of the COVID-19 vaccine differed across different phases of the epidemic marked by China’s pre- and post-2021 national vaccination policy.

Our study location was Qingdao, a high per capita income and major transport and manufacturing port city in eastern Shandong Province. Administering 217,185 dosages pre-2021 [39–63], and 24.1 million vaccine dosages by January 2022 under China’s 2021 national vaccination policy [64], Qingdao and Shandong also faced local COVID-19 outbreaks [65]. Understanding vaccination preferences in China is particularly important given the risk of the Omicron variant, which was resurgent in Hong Kong in February 2022, with, under China’s zero-COVID-19-tolerance policy, flare-ups contained in mainland China. Our
study will inform the rollout of China’s national vaccination program and provide valuable information for future vaccination policy design to meet recurring COVID-19 risks.

2. Materials and Methods

2.1. Identification of Attributes and Levels

Based on the existing literature [41,66–69], expert interviews and a pilot study, six key attributes (vaccine effectiveness, vaccine-related side effects, vaccination sites, duration of vaccine protection, acquaintances vaccinated and perception of risk) were identified [41]. The probability of oneself and close acquaintances (friends and family) being infected with COVID-19 was assigned 100/100,000, 6/100,000 and 1/100,000 probabilities. Other attribute levels followed the COVID-19, seasonal influenza, H1N1 and hepatitis B vaccine literature [41,66–69]. Vaccine effectiveness comprised three levels: 40%, 60% and 85%. Side effects consisted of three levels: 1/100,000, 10/100,000 and 50/100,000. Reflecting the nation’s healthcare provider system, vaccination sites were distinguished by level 1 (village clinic or community health station), level 2 (township or community health centre) and level 3 (county hospital or above) facilities [41]. The duration of protection was 6 months, 1 year and more than 2 years, and the percentage of acquaintances vaccinated was set at 3 levels: 30%, 60% and 90% [41]. A list of attributes and levels are shown in Table 1.

Table 1. Attributes and Levels Used in the Discrete Choice Experiment.

| Attributes                          | Levels                      | Descriptions                                      |
|------------------------------------|-----------------------------|---------------------------------------------------|
| Vaccine effectiveness              | 40%                         | Protects 40% of vaccinated                        |
|                                    | 60%                         | Protects 60% of vaccinated                        |
|                                    | 85%                         | Protects 85% of vaccinated                        |
| Self-assessed vaccine-related side effects | 50/100,000                | 50 out of 100,000 risk of severe side effects |
|                                    | 10/100,000                  | 10 out of 100,000 risk of severe side effects |
|                                    | 1/100,000                   | 1 out of 100,000 risk of severe side effects |
| Vaccination sites                  | Level 1                      | Village clinic or community health station        |
|                                    | Level 2                      | Township or community health centre              |
|                                    | Level 3                      | County hospital and above                         |
| Duration of vaccine protection     | six months                   | Six months of vaccine protection                  |
|                                    | one year                     | One year of vaccine protection                    |
|                                    | More than two years          | More than two years                               |
| Acquaintances vaccinated           | 30%                         | 30% of your family, friends and acquaintances already vaccinated |
|                                    | 60%                         | 60% of your family, friends and acquaintances already vaccinated |
|                                    | 90%                         | 90% of your family, friends and acquaintances already vaccinated |
| Risk perception (probability including yourself and acquaintances being infected with COVID-19) | 100/100,000 | 100 out of 100,000 contracting COVID-19 |
|                                    | 6/100,000                   | 6 out of 100,000 contracting COVID-19            |
|                                    | 1/100,000                   | 1 out of 100,000 contracting COVID-19            |

2.2. Experimental Design

Consistent with Leng et al. [41], D-efficient partial profile design was used to guarantee that preference parameters can be estimated with maximal precision. Twenty-four hypothetical two-alternative choice tasks were created. For each choice task, respondents were asked to choose which vaccine they would prefer. To reduce the cognitive burden on respondents, these 24-choice tasks were divided randomly into 3 different versions of the questionnaire. Each version contained 8 choice tasks. An example of a choice task is shown in Table 2.
Table 2. Choice set.

| Q1                        | Vaccine A         | Vaccine B         |
|---------------------------|-------------------|-------------------|
| Vaccine effectiveness     | 40%               | 60%               |
| Vaccine-related side effects | 10/100,000        | 50/100,000        |
| Vaccination sites         | Level 1           | Level 2           |
| Duration of vaccine protection | one year          | six months        |
| Acquaintances vaccinated  | 30%               | 60%               |
| The probability of infection with COVID-19 | 100/100,000 | 6/100,000 |

Which vaccine do you prefer?

2.3. Survey

During May 2021, a two-part questionnaire collected information on respondents’ background characteristics and DCE preferences. The rate of recruitment of the survey was 95%. A pilot survey was conducted with 20 respondents in order to quality-assure phraseology and question layout. The final version was determined as a two-part questionnaire, of which part one sought respondents’ background characteristics, comprising sex, age (18–30 years old; 31–50 years old; over 50 years old), location (urban or rural based on household registration), educational attainment (low education ≤ 12 years of schooling; medium education between 13 and 16 years of schooling; high education more than 16 years of schooling), job status (farmer; public institutions; company employees; other), self-identified income level (low, medium or high income level) and family relationships (living with the elderly and children). Part two contained 8 binary choice tasks investigating preference trade-offs for vaccine effectiveness, vaccine side effects, duration of protection, vaccination sites, percentage of acquaintances vaccinated and perception of risk. The study was approved by Nanjing Medical University Ethics Committee (No. 2020565).

2.4. Sample

The inclusion criteria required all respondents to be over 18 years old and without cognitive impairment. Using a simply random sampling method, 849 respondents in Qingdao were recruited and administered a face-to-face survey by trained researchers, with interviewees given a small monetary token at the completion of the survey. The final sample accounted for a total of 13584 observations, which is sufficient to meet the minimal research sample size requirement set by Orme [70].

2.5. Data Analysis

Following commonly used statistical analysis methods for DCE experiments, we adopted the conditional logit model (CLM) to measure individual preferences [41]. In addition, mixed logit models (MLM) and latent class models (LCM) were specified to capture individual preferences heterogeneity. All attribute levels were represented as dummy variables with a selected level for each attribute set as the reference level. Modifying Leng et al.’s model [41], the CLM used to measure individual utility was:

\[
U_{ijs} = \beta_1 \text{effect(60)}_{ijs} + \beta_2 \text{effect(85)}_{ijs} + \beta_3 \text{sideeffect(10)}_{ijs} \\
+ \beta_4 \text{sideeffect(1)}_{ijs} + \beta_5 \text{site(second level)}_{ijs} \\
+ \beta_6 \text{site(third level)}_{ijs} + \beta_7 \text{protection(1yr)}_{ijs} \\
+ \beta_8 \text{protection(2yr)}_{ijs} + \beta_9 \text{acquaintances(60)}_{ijs} \\
+ \beta_{10} \text{acquaintances(90)}_{ijs} + \beta_{11} \text{probinfected(6)}_{ijs} \\
+ \beta_{12} \text{probinfected(100)}_{ijs} + \epsilon_{ijs}
\]  

(1)

where \(U_{ijs}\) represents the utility of respondent \(i\) for scenario \(j\) in the choice set \(s\) (where \(j = 1,2; s = 1,2,3\)). \(\beta\) is a vector of parameters for each attribute level and utility. \(\epsilon_{ijs}\) is the random utility error.
MLM allow unobserved preference heterogeneity to be modelled through relaxing the independence and irrelevance assumption (IIA) of the error term [71]. We specified that following MLM model:

\[ U_{ij} = \beta_1\text{effect}(60)_{ij} + \beta_2\text{effect}(85)_{ij} + \beta_3\text{sideeffect}(10)_{ij} + \beta_4\text{sideeffect}(1)_{ij} + \beta_5\text{site(secondlevel)}_{ij} + \beta_6\text{site(thirdlevel)}_{ij} + \beta_7\text{protection(1yr)}_{ij} + \beta_8\text{protection(2yr)}_{ij} + \beta_9\text{acquaintances}(60)_{ij} + \beta_{10}\text{acquaintances}(90)_{ij} + \beta_{11}\text{probinfected}(6)_{ij} + \beta_{12}\text{probinfected}(100)_{ij} + \varepsilon_{ij} \] (2)

where \( U_{ij} \) represents the utility of respondent \( i \) for scenario \( j \) in the choice set \( s \) (where \( j = 1,2 \); \( s = 1,2,3 \)).

The LCM is another method for modelling how individual characteristics influence choices [41]. The model assumes that individual preferences are shaped by attributes which may vary across unobservable sub-classes [72]. Following Leng et al. [41], we selected the three-class model with six sociodemographic covariates based on Akaike information criteria (AIC) and Bayesian information criteria (BIC) comparisons across classes and covariates [73]. The central utility function for individual \( i \) belonging to subclass \( q \) for scenario \( j \) in choice sets was modelled through the logit function:

\[ U_{ij|q} = \beta_{1|q}\text{effect}(60)_{ij|q} + \beta_{2|q}\text{effect}(85)_{ij|q} + \beta_{3|q}\text{sideeffect}(10)_{ij|q} + \beta_{4|q}\text{sideeffect}(1)_{ij|q} + \beta_{5|q}\text{site(secondlevel)}_{ij|q} + \beta_{6|q}\text{site(thirdlevel)}_{ij|q} + \beta_{7|q}\text{protection(1yr)}_{ij|q} + \beta_{8|q}\text{protection(2yr)}_{ij|q} + \beta_{9|q}\text{acquaintances}(60)_{ij|q} + \beta_{10|q}\text{acquaintances}(90)_{ij|q} + \beta_{11|q}\text{probinfected}(6)_{ij|q} + \beta_{12|q}\text{probinfected}(100)_{ij|q} + \varepsilon_{ij|q} \] (3)

3. Results

3.1. Sample Characteristics

Table 3 reports key characteristics of the study sample. Out of 849 respondents, the majority of respondents were male (53.4%), aged between 31–50 years old (49%), married (77.7%), on an average income level (75%), from rural areas (64.5%) and had less than 12 years of education (56.7%). As is also shown in Table 3, social relationship dynamic factors were captured, with 12.6% of respondents having older family members at home and 23.56% living with children.

| Characteristics                  | n  | %     |
|----------------------------------|----|-------|
| Sex                              |    |       |
| Male                             | 453| 53.357|
| Female                           | 396| 46.643|
| Age                              |    |       |
| Age 18–30                        | 168| 19.788|
| Age 31-50                        | 416| 48.999|
| Age 51+                          | 265| 31.213|
| Marital status                   |    |       |
| married                          | 660| 77.739|
| unmarried/widowed/divorced       | 189| 22.261|
| Residence                        |    |       |

Table 3. Characteristics of the study sample (\( n = 849 \)).
Table 3. Cont.

| Characteristics                | n   | %         |
|-------------------------------|-----|-----------|
| urban area                    | 301 | 35.453    |
| rural area                    | 548 | 64.547    |
| Years of education            |     |           |
| low education (≤12 years)     | 481 | 56.655    |
| medium education (13—≤16 years) | 263 | 30.978    |
| high education (>16 years)    | 105 | 12.367    |
| Occupation                    |     |           |
| farmer                        | 257 | 30.271    |
| government/public institution staff | 180 | 21.201    |
| company employees (including migrant workers, individual businesses, etc.) | 290 | 34.158    |
| Other (including retired, student) | 122 | 14.370    |
| Household yearly income       |     |           |
| low income level              | 114 | 13.428    |
| medium income level           | 637 | 75.029    |
| high income level             | 98  | 11.543    |
| Elderly at home               | 107 | 12.603    |
| Children at home              | 200 | 23.557    |

3.2. Estimation of Parameters

Table 4 presents the results of the conditional logit model. All variables were statistically significant (p < 0.01), except for level 3 vaccination sites and acquaintances vaccinated. Vaccine effectiveness, vaccine-related side effects, followed by duration of protection and perceived probability of infection of individuals/acquaintances were the four most important attributes that influenced individual decision making. Vaccination sites and percentage of acquaintances vaccinated were the two least influential variables. Individuals were more likely to accept the vaccine when it was judged more effective, had fewer side effects and exhibited a longer duration of protection. We also found that respondents reported higher vaccination acceptance rates when there was a high percentage of acquaintances vaccinated around them, and respondents preferred Level 2 township or community health centres over Level 1 village clinics and Level 3 county hospitals and above.

Table 4. Conditional logit model of respondent preferences.

| Attribute                                | ß   | SE   | p Values | 95% CI       |
|------------------------------------------|-----|------|----------|--------------|
| Vaccine effectiveness (reference = 40%)  |     |      |          |              |
| 60%                                       | 0.423 | 0.036 | 0.000    | 0.351, 0.494 |
| 85%                                       | 0.806 | 0.041 | 0.000    | 0.727, 0.886 |
| Vaccine-related side effects (reference = 50/100,000) |     |      |          |              |
| 10/100,000                               | 0.251 | 0.035 | 0.000    | 0.182, 0.320 |
| 1/100,000                                | 0.432 | 0.037 | 0.000    | 0.358, 0.507 |
| Vaccination sites (reference = Level 1)  |     |      |          |              |
| level 2                                  | 0.141 | 0.037 | 0.000    | 0.067, 0.214 |
| level 3                                  | −0.067 | 0.036 | 0.063    | −0.138, 0.004 |
| Duration of vaccine protection (reference = six months) |     |      |          |              |
| one year                                 | 0.245 | 0.037 | 0.000    | 0.173, 0.316 |
| more than two years                      | 0.350 | 0.036 | 0.000    | 0.279, 0.421 |
| Acquaintances vaccinated (reference = 30%) |     |      |          |              |
| 60%                                       | 0.031 | 0.037 | 0.409    | −0.042, 0.103 |
| 90%                                       | 0.093 | 0.037 | 0.011    | 0.021, 0.165 |
Table 4. Cont.

| Attribute                                                                 | β     | SE   | p Values | 95% CI       |
|---------------------------------------------------------------------------|-------|------|----------|--------------|
| The probability of respondents/acquaintances infected (reference = 1/100,000) |       |      |          |              |
| 6/100,000                                                                 | 0.221 | 0.037| 0.000    | 0.148, 0.293 |
| 100/100,000                                                               | 0.346 | 0.036| 0.000    | 0.274, 0.417 |

Model fit
- Observations = 13,584
- Respondents = 849
- Prob > chi2 = 0.000
- Pseudo R2 = 0.0857
- LR chi2(13) = 4304.62
- AIC = 8633.24
- BIC = 8723.44

Table 5 presents the results of the MLM. Vaccine effectiveness, vaccine-related side effects, the probability of respondent and acquaintances being infected and the risk of infection were all statistically significant (p < 0.01). The percentage of acquaintances vaccinated, when considered as an individual-specific variable, became the third-most dominant force for vaccine acceptance. This suggests that high acquaintance-vaccination rates induce individuals to vaccinate, perhaps appealing to pro-social morals or reflecting peer pressure.

Table 5. Mixed Logistic Regression Models of Patient Preferences.

| Variables                      | β     | SD   | p Values | 95% CI       |
|--------------------------------|-------|------|----------|--------------|
| Vaccine effectiveness (reference = 40%)                                    |       |      |          |              |
| 60%                           | 0.543 | 0.005| 0.001    | 0.465, 0.621 |
| 85%                           | 1.537 | 1.164| 0.001    | 1.418, 1.656 |
| Vaccine-related side effects (reference = 50/100,000)                      |       |      |          |              |
| 10/100,000                    | 0.658 | 0.535| 0.001    | 0.581, 0.736 |
| 1/100,000                     | 1.402 | 1.326| 0.001    | 1.285, 1.519 |
| Vaccination sites (reference = level 1)                                    |       |      |          |              |
| level 2                       | 0.055 | 0.885| 0.187    | −0.027, 0.137 |
| level 3                       | −0.361| 0.637| 0.001    | −0.445, −0.276 |
| one year                      | −0.048| −0.268| 0.197 | −0.122, 0.025 |
| more than two years           | 0.096 | 0.408| 0.013    | 0.020, 0.171 |
| Acquaintances vaccinated (reference = 30%)                                  |       |      |          |              |
| 60%                           | 0.226 | 0.014| 0.001    | 0.149, 0.304 |
| 90%                           | 0.440 | 0.058| 0.001    | 0.361, 0.519 |
| 6/100,000                     | 0.252 | −0.392| 0.001 | 0.175, 0.329 |
| 100/100,000                   | 0.374 | 0.744| 0.001    | 0.290, 0.459 |

Table 6 presents the results of the LCM. Preference heterogeneity can be clearly seen for different attributes across the three sub-classes. There is strong evidence that supports the existence of latent classes based on socioeconomic covariates, such as age, education, urban/rural residence, income and social relationships. Class 3 was chosen as the reference class and accounted for 31.2% of the total sample. Class 3 also displayed attribute preferences that closely resembled the full conditional logit model.
Table 6. Latent class logit model of patient preferences.

| Attribute                          | Class 1     |          |          | Class 2     |          |          | Class 3     |          |          |
|------------------------------------|-------------|----------|----------|-------------|----------|----------|-------------|----------|----------|
|                                    | β  | SE     | p Value | β  | SE     | p Value | β  | SE     | p Value |
| Vaccine effectiveness (reference = 40%) |   |         |         |   |         |         |   |         |         |
| 60%                                | 3.007 | 0.333  | 0.000   | −0.052 | 0.080  | 0.502  | 0.902 | 0.114  | 0.000  |
| 85%                                | 6.344 | 0.771  | 0.000   | 0.060  | 0.086  | 0.488  | 1.351 | 0.149  | 0.000  |
| Vaccine-related side effects (reference = 50/100,000) |   |         |         |   |         |         |   |         |         |
| 10/100,000                         | −0.027 | 0.390  | 0.946   | 0.633  | 0.070  | 0.000  | 0.261 | 0.089  | 0.000  |
| 1/100,000                          | 0.093  | 0.349  | 0.791   | 1.247  | 0.095  | 0.000  | −0.442 | 0.119  | 0.000  |
| Vaccination sites (reference = first level) |   |         |         |   |         |         |   |         |         |
| second level                       | 3.317 | 0.859  | 0.000   | 0.276  | 0.072  | 0.000  | −0.388 | 0.112  | 0.000  |
| third level                        | −2.244 | 0.278  | 0.000   | −0.181 | 0.079  | 0.021  | 0.684  | 0.113  | 0.000  |
| Duration of vaccine protection (reference = six months) |   |         |         |   |         |         |   |         |         |
| one year more than two years       | 1.732 | 0.264  | 0.000   | 0.082  | 0.073  | 0.259  | 0.098  | 0.105  | 0.350  |
| Acquaintances vaccinated (reference = 30%) |   |         |         |   |         |         |   |         |         |
| 60%                                | −1.259 | 0.366  | 0.001   | 0.081  | 0.067  | 0.228  | 0.044  | 0.103  | 0.679  |
| 90%                                | −2.354 | 0.348  | 0.000   | 0.474  | 0.075  | 0.000  | −0.112 | 0.107  | 0.293  |
| The probability of individuals/acquaintances infected (reference = 1/100,000) |   |         |         |   |         |         |   |         |         |
| 6/100,000                          | 0.667  | 0.476  | 0.117   | −0.536 | 0.077  | 0.000  | 0.10   | 0.111  | 0.363  |
| 100/100,000                        | 2.588  | 0.554  | 0.000   | −1.333 | 0.088  | 0.000  | −0.081 | 0.093  | 0.386  |
| Class probability model            |   |         |         |   |         |         |   |         |         |
| age                                | 0.041  | 0.159  | 0.795   | −0.281 | 0.131  | 0.032  | -      | -      | -      |
| education                          | 0.213  | 0.181  | 0.239   | 0.128  | 0.144  | 0.374  | -      | -      | -      |
| urban/rural residence              | 0.477  | 0.238  | 0.045   | 0.528  | 0.186  | 0.005  | -      | -      | -      |
| average monthly household income   | −0.185 | 0.209  | 0.374   | −0.431 | 0.170  | 0.011  | -      | -      | -      |
| elderly at home                    | −0.131 | 0.297  | 0.658   | −0.746 | 0.316  | 0.018  | -      | -      | -      |
| children at home                   | −0.110 | 0.266  | 0.678   | −0.030 | 0.232  | 0.870  | -      | -      | -      |
| constant                           | −1.126 | 0.772  | 0.144   | 0.894  | 0.525  | 0.089  | -      | -      | -      |
| Average                            | 0.220  | 0.468  | 0.312   |          |        |        |        |        |        |

For Class 2, vaccine side effects, probability of individuals infected and vaccination sites were the three most influential attributes. Duration of protection (more than year) and acquaintances vaccinated (90%) were also statistically significant. From class assignment probabilities, when compared against the reference class, we observe that Class 2 respondents exhibited the characteristics of younger age, lower income, living without elderly family members and coming from rural regions. Our results suggest that Class 2 respondents with the above characteristics were less likely to vaccinate.

Class 1 respondents were from rural regions and exhibited preferences that were significantly different from the other two classes. Vaccine effectiveness, vaccination sites and proportion of acquaintances vaccinated were all statistically significant. Odd ratios suggest that these attributes significantly influenced preference utility for Class 1 individuals. In
addition, we observe that the perception of risk also had a profound effect on Class 1 individuals, with vaccination uptake increasing significantly with perception of risk.

Following Leng et al. [41], a marginal analysis was conducted to better understand how vaccination uptake rates change across different attribute levels. We selected a reference vaccine scheme with characteristics set as 40% vaccine effectiveness, 50/100,000 risk of severe side effects, village clinic or community health station administration, protection duration of 6 months, 60% of acquaintances vaccinated and self-determined 100/100,000 risk of infection for individual/acquaintances. Marginal analysis showed that when vaccine effectiveness increased from 40% to 85%, acceptance rates increased by 26%. When vaccine-related side effects reduced from 50/100,000 to 1/100,000, respondents reported a 14.1% increase in willingness to vaccinate. The full marginal analysis results are presented in Figure 1, where the x-axis represents the baseline vaccine scheme.

| Attribute                  | Changes in probability uptake |
|----------------------------|-------------------------------|
| 100/100,000 infected       |                               |
| 6/100,000 infected         |                               |
| 90% vaccinated             |                               |
| 30% vaccinated             |                               |
| ≥2 years protection        |                               |
| 1 year protection          |                               |
| level 3 sites              |                               |
| level 2 sites              |                               |
| 1/100,000 sideeffect       |                               |
| 10/100,000 sideeffect      |                               |
| 85% effectiveness          |                               |
| 60% effectiveness          |                               |

Figure 1. Changes in probability uptake.

4. Discussion

Compared to the existing vaccination-preference literature conducted under China’s 2021 national vaccination policy [55–58], our study adopts a broader framework incorporating social relationships (percentage of acquaintances vaccinated and living with the elderly and the young) and cognition (perception of risk). In addition, our study is also one of the first to assess individual vaccination preference changes since the implementation of the 2021 national vaccination policy.

Our results show individuals preferred vaccines that were more effective, had fewer side effects and provided longer protection periods. These results are broadly consistent with the existing pre-2021 and post-2021 national vaccination policy literature [40,41,55–58]. Similarly to Leng et al.’s pre-national vaccination period study [41], MLM showed that individuals with a higher percentage of acquaintances vaccinated were more likely to vaccinate. ICU workers in the pre-2021 national vaccination policy period also exhibited similar findings [51]. Our LCM revealed clear preference heterogeneity based on social demographic covariates comprising age, education, region, income and social relations (living with the young and old). For Class 1 individuals, vaccine effectiveness, vaccination sites and percentage of acquaintances vaccinated significantly influenced vaccination attitudes. This is in contrast to Class 2 and three individuals, where β estimates suggest that the marginal effects of these attributes from the mean were less significant. For Class 2, younger people with higher education were less likely to vaccinate. This was in line with
the results of studies conducted both before and after the implementation of the 2021 national vaccination policy [41,55].

Our study sheds new light on how individual preferences have changed under the 2021 national vaccination policy. In contrast to Leng et al.’s [41] pre-2021 study, the percentage of acquaintances vaccinated was not a statistically significant attribute. A possible explanation is that public concerns regarding the vaccine had diminished through better pro-vaccine education and communication. Further, respondents preferred township community health centres over county hospitals or village clinics. This is in contrast to previous studies, where respondents displayed mistrust towards primary healthcare services and preferred county hospitals [41]. Perhaps community health centres were seen as vaccination sites and county hospitals as disease-treatment centres. In contrast to the pre-2021 study by Liu et al. [55], which found that there was no clear difference in vaccine willingness between rural and urban regions, we found that respondents from Class 1 of our LCM reported that rural regions were more likely to accept the vaccine \( (p < 0.05) \). We also observed that family urban/rural residency had an effect on Class 2 respondents’ preferences. Importantly, respondents living with elder household members were more likely to vaccinate, whereas those living with the young were not.

We also considered individual cognition as an attribute in our CLM, which has not been assessed in previous studies. Marginal analysis shows that when the perceived probability of infection rose from 1/100,000 to 100/100,000, vaccination uptake probability increased by 11.3%. Vaccine effectiveness, vaccine-related side effects and duration of protection were the three most influential factors alongside the perception of risk. Compared to pre-2021 studies [40,41], where vaccination effectiveness and vaccine-related side effects were the two most important attributes, we found that the importance of protection duration has risen relative to the other factors. This suggests that people’s concerns regarding the vaccine have shifted from safety and effectiveness to longer protection duration. With global research showing the reduction in vaccine effectiveness, particularly against the Omicron variant [74,75], vaccines with longer protection periods were increasingly preferred.

This study has a number of limitations. First, we adopted a simple random sampling method in Qingdao, since COVID-19 travel restrictions restricted inter-city or inter-province face-to-face DCE interviews. As a result, the sample may not have the same representative power as a stratified random sampling method. Second, we controlled for the number of dosages in our study, which reflects the majority of administrated vaccines in China at the time. However, some vaccines administered require more than two dosages for full vaccination. Future preference studies may need to include the number of doses as an attribute and further investigate vaccination preferences for booster doses.

5. Conclusions

Our study investigated individual vaccination preferences under China’s 2021 national COVID-19 two-dosage, free and voluntary national vaccination program. The CLM, MLM and LCM showed that in addition to vaccine-specific attributes (vaccine effectiveness, vaccine-related side effects, vaccination sites, duration of protection) and sociodemographic characteristics, social relations (including percentages of acquaintances vaccinated and living with the old) and cognition (perceived risk of infection) were important factors influencing individual preference.

Our study compared findings with previous research conducted pre-2021 national vaccination policy. We found that under the 2021 national vaccination policy, individuals continued to prefer vaccines with better efficacy, longer protection periods and higher safety standards. We also discovered that when compared to studies conducted in the pre-2021 period, safety concerns about the vaccine have diminished and respondents’ preferences have shifted towards longer protection and accessibility.

Our study will contribute to the current efforts in the vaccine rollout and inform the government in developing more effective vaccination policies in the future. With many Chinese provinces starting to implement booster doses, we believe that vaccination policies...
aiming to increase accessibility, targeting individuals with higher risk of infection and emphasising individual risk will result in higher vaccination uptake. Health authorities should be aware that a high acquaintance-vaccination rate induced individuals to vaccinate. Social relationships, especially the desire to protect elders from infection when living together, should be a feature of information campaigns in the rollout of China’s vaccine programs.

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