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**Original Article**

# Preferences for a new vaccine against an emerging infectious disease: A discrete choice experiment among Millennials and Generation Z in Vietnam

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## Abstract

The rising threat of emerging infectious diseases (EIDs) highlights the need to understand factors influencing vaccine adoption. The aim of this study was to explore the willingness to vaccinate and vaccine acceptance preferences among Millennials and Generation Z in Vietnam. Convenience sampling was conducted, after which a traditional discrete choice experiment was performed. Participants were tasked with selecting their preferred options from a set of eight vaccination choice tasks, each consisting of two alternatives distinguished by varying degrees of vaccine efficacy, side effects, influential endorsements, trusted sources, and disease susceptibility through literature reviews, expert interviews, and pilot tests. A minimum sample size of 375 participants was recruited via Internet-based and paper-based surveys. A latent class model was used to explore the heterogeneity in participant preferences, while a mixed logit model was employed to facilitate the computation of the predicted probabilities of vaccine acceptance. Among the 818 included participants, 494 (60.4%) were Millennials generation. The predicted probability of vaccine acceptance was 61.8%, with slight differences between Millennials (62.4%) and Generation Z (61.0%). Four latent classes with significant preference variations were identified. Class 1 (38%) was influenced by vaccine effectiveness, side effects, and health authority recommendations, showing lower opt-out rates. Class 2 (28%) prioritized vaccine effectiveness and authority recommendations but had higher opt-out rates and a stronger religious influence. Class 3 (23%) focused on vaccine effectiveness and side effects, with a tendency to opt-out. Class 4 (11%) valued high vaccine effectiveness and advice from family, with infection risks to family or local areas being significant motivators. Influential voices were more important in Classes 1 and 2, while side effects and effectiveness were prioritized in Classes 3 and 4. In conclusion, Vietnamese Millennials and Generation Z preferred vaccination when the vaccine had 90% efficacy, mild to moderate side effects, endorsements from the Ministry of Health, positive recommendations from family and social networks, and high exposure risks from family members.

**Keywords**: Willingness to accept, vaccines, emerging infectious diseases, discrete choice, Vietnam

## Introduction

Emerging infectious diseases (EIDs) are illnesses that have newly appeared in a population, rapidly increased in incidence or geographic range, or are caused by priority pathogens listed by



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the National Institute of Allergy and Infectious Diseases [1]. EIDs pose an urgent global challenge due to factors such as climate change, natural disasters, and rapid urbanization [2, 3]. This urgency was highlighted by the coronavirus disease 2019 (COVID-19) pandemic and recurring EIDs outbreaks [2]. A recent study estimated a 2% annual probability of a pandemic similar to COVID-19, with this likelihood potentially tripling in the next decade [4].

Vaccines are critical for controlling epidemics and preventing pandemics [5]. However, vaccine effectiveness depends on public willingness to get vaccinated [2] and vaccine hesitancy—reluctance or refusal to vaccinate despite availability—remains a global health threat [6-9]. Previous studies have highlighted generational differences (Baby Boomers, Generation X, Millennials, and Generation Z (Gen Z) in vaccine hesitancy, influenced by work-related attitudes and social media [10-12]. Notably, social media strongly affects Gen Z [10] and Millennials [12], contributing to negative perceptions and misinformation about vaccines [13]. A study on COVID-19 vaccine hesitancy in the United States found that 53.8% of Gen Z participants refused the first vaccine dose, compared to 19.7% of Generation X and 1.7% of Baby Boomers [14].

To improve vaccine acceptance rates, public health campaigns must address generational disparities in vaccine hesitancy [11]. Such hesitancy can lead to disease outbreaks, higher mortality rates, and wasted medical resources [15]. While significant research exists, few studies have examined preference-related factors in vaccination during emerging epidemics. To the best of our knowledge, only one study conducted in Uganda has addressed this issue in the context of EIDs [2]. Similar studies conducted in Japan and the Netherlands did not focus on EIDs [16,17]. Understanding public preferences for new vaccines is essential for shaping effective national and international policies and for developing timely epidemic response plans [2,17]. Discrete choice experiment (DCE) is a common method for eliciting these preferences by involving individuals making trade-offs to choose alternatives they perceive as most beneficial [18]. DCE techniques help policymakers understand the trade-offs individuals are willing to make regarding various service attributes and levels of need [19]. DCE data can estimate the relative value of attributes and individuals' willingness to accept specific health services [19]. Therefore, organizations such as the Medical Device Innovation Consortium recommend using DCE in health research [20].

Many countries around the globe, including Vietnam, continue to face a high risk of emerging and re-emerging infectious diseases, with the potential to escalate into pandemics [21]. In addition, vaccine hesitancy has been reported more frequently in Southeast Asia, including in Vietnam, than in other regions [6]. During the early stages of the COVID-19 pandemic in Vietnam, vaccination rates were low: by June 19, 2021, only 2.31% of the population had received at least one dose, and just 0.06% were fully vaccinated [22]. By August 30, 2021, these rates increased to approximately 20% had received at least one dose and 2.5% were fully vaccinated [22]. To the best of our knowledge, no research has explored preferences for accepting a new vaccine against emerging epidemics among Vietnamese, particularly Millennials and Gen Z. The aim of this study was to address this gap by exploring the willingness to vaccinate and vaccine acceptance preferences against an EID among Millennials and Gen Z in Vietnam.

# Methods

## Study design and setting

A cross-sectional study was conducted from August 2023 to May 2024 in Vietnam among Vietnamese adults who belong to Millennials (born 1982–2000) and Gen Z (born 2001 onward) [9]. The DCE method was used to design the questionnaire. The process of implementing the DCE method includes four stages: (1) determining attributes and attribute levels, (2) experimental design, (3) data collection, (4) data analysis and interpretation of results. The data collection was conducted using two different methods, both online and paper-based surveys.

## Sampling strategy and participant criteria

Sample size calculation was performed using Orme's calculation [23], which required for the main effects depending on the number of choice tasks, the number of alternatives, and the number of analysis cells, as described previously [23]. In this study, the number of choice tasks was 8, the number of alternatives was 2 (Scenario A and Scenario B), and the highest number of levels in an

attribute was 4 (**Table 1**), requiring 375 participants as the minimum sample size. Consecutive sampling was employed to recruit the sample. A convenience sample was recruited to participate in this study using two methods: an online survey using the Google Forms platform and a paper-based survey in public places. All Vietnamese aged 18 and 42 who could read and speak Vietnamese were considered eligible. Those who gave incorrect answers on the choice set, including a dominant scenario or selecting only one choice throughout the DCEs section, were excluded from the analysis.

## Selection of attributes and attribute levels of DCE

The validity of a DCE, as an attribute-based method, largely depends on the researcher's precise identification of the attributes and levels of the good or service (such as vaccination) [24]. In this study, the attributes and their levels were identified and made by reviewing relevant DCE in PubMed and selecting the most frequently occurring ones. A combination of keywords “discrete choice” and “vaccine preferences” was employed. This step yielded a total of 40 attributes and then the duplicating attributes were shortened, leaving 13 attributes, including vaccine effectiveness, vaccine safety, vaccine side effects, duration of vaccine immunity, primary and secondary protection of the vaccine, accessibility of the vaccine application, costs, limitations if not vaccinated (cannot travel etc.), vaccination recommendations from professionals, advice from people around (family, friends), information about vaccines in the media (television, social networks), disease risks and intensive effects after vaccination. This list was refined through pilot tests and interviews with five experts: two general practitioners, a clinical pharmacist, and two health economics experts. Pilot tests involved 30 participants interviewed face-to-face (15 were Millennials and 15 were Gen Z). Participants were presented with a list of 13 attributes identified from the literature review and were asked to choose the five attributes they considered to be the most important priorities influencing their vaccination decisions.

As a result, the seven most chosen attributes received were vaccine effectiveness, side effects, influential voices, trusted individuals, disease risks, cost and accessibility of the vaccine. However, since the vaccines were provided free of charge and available in all provinces and cities of Vietnam (based on the context of the COVID-19 vaccine), the last two attributes were excluded. The initial set of attributes and levels obtained through the pilot were then presented to experts for evaluation. Attributes were rated from important to unimportant, while levels were rated from appropriate to inappropriate, both on a five-point rating scale. Experts also had the opportunity to comment on each attribute and level, suggested additional levels for each attribute, and suggested new attributes for consideration. Finally, five attributes and their levels were included in the final design: vaccine effectiveness, side effects, influential voices, trusted individuals, and disease risks (**Table 1**).

Table 1. Attributes and levels used in formulating the vaccine conditions during the study

| Attributes | Levels | Descriptions |
|---|---|---|
| Vaccine effectiveness | (1) 90%<br>(2) 60% | Is the effectiveness of a vaccine, expressed as the percentage of the population that the vaccine protects. |
| Side effects | (1) Mild to moderate (very common)<br>(2) Abnormal (less common)<br>(3) Serious incident (very rare) | These are side effects that appear after vaccination. |
| Influential voices | (1) Ministry of Health<br>(2) Doctor<br>(3) Famous people on social networks | Vaccination recommendations given by the Ministry of Health, doctors or famous figures on social networks. |
| Trusted individuals | (1) A family member/friend advises you to take the vaccine<br>(2) A family member/friend advises you not to take the vaccine<br>(3) A religious leader advises you to take the vaccine<br>(4) A religious leader advises you not to take the vaccine | Advice from people you trust. |

| Attributes | Levels | Descriptions |
|---|---|---|
| Disease risk | (1) Your family members<br>(2) Cases in your living resident<br>(3) Cases in a distant region of Vietnam<br>(4) Cases in a neighboring country | Is a source of exposure to disease-causing viruses. |

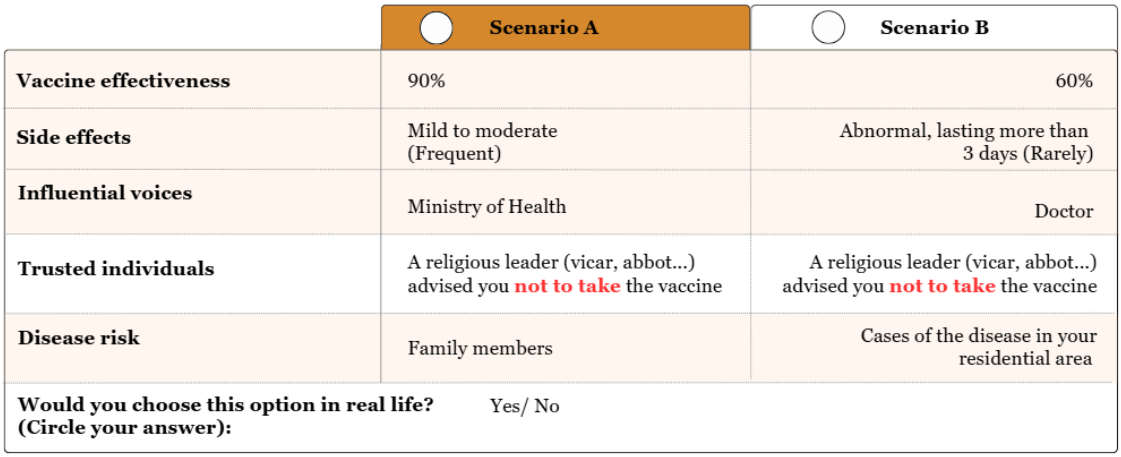
## Study procedures

The number of choice sets was reduced using a fractional factorial design in SAS software version 10 (JMP Statistical Discovery LLC, New York, USA), applying a D-efficient design based on pilot survey data from 30 participants. This resulted in 24 selection tasks, divided into three blocks (partitions of the choice questions that promote response efficiency by reducing the necessary cognitive effort for each respondent [25]) with eight choice sets each, following the ISPOR guidelines [26]. Each set included two alternatives—Scenarios A and B—along with an 'opt-out' option using a dual-response design. This opt-out was necessary since, as in real life, respondents are not obliged to take a vaccination. The overlapping technique, used for one random attribute in each task, minimized complexity and cognitive burden. An example choice set is depicted in **Figure 1**. Data were collected using a Google Form shared on social networks and through a paper-based survey. For the online survey, progress indicators and error notifications were included to encourage completion. Both online and paper-based formats were employed to capture responses from both social media users and non-users.

## Questionnaire

The self-report questionnaire comprised two parts: (1) a DCE section with eight choice tasks (questions) and (2) a section on demographic characteristics with 11 questions about year of birth, sex, residence location, educational level, religious status, occupational status, monthly income, previous history of infectious diseases, previous vaccination record, health status and reason for vaccine hesitancy. The DCE section consisted of three blocks, and each block consisted of eight main questions, of which each main question had two alternatives (Scenario A and Scenario B); therefore, there were 48 scenarios in total.

Participants who consented were given a table outlining the attributes and epidemic context, along with a clear example of a choice task before beginning preference elicitation. They evaluated two hypothetical vaccines per task (Scenarios A and B) and selected between them. The questionnaire opened with a description of a hypothetical disease outbreak and the government's introduction of a new vaccine in Vietnam, highlighting its effectiveness and accessibility. The scenario was described as follows: 'A disease outbreak is ongoing, with risks of infection and potential mortality upon exposure to carriers. In response, the government has introduced a new, free vaccine, previously unused in Vietnam, requiring only a single dose and available nationwide.'



| | Scenario A | Scenario B |
|---|---|---|
| **Vaccine effectiveness** | 90% | 60% |
| **Side effects** | Mild to moderate (Frequent) | Abnormal, lasting more than 3 days (Rarely) |
| **Influential voices** | Ministry of Health | Doctor |
| **Trusted individuals** | A religious leader (vicar, abbot...) advised you **not to take** the vaccine | A religious leader (vicar, abbot...) advised you **not to take** the vaccine |
| **Disease risk** | Family members | Cases of the disease in your residential area |
| **Would you choose this option in real life? (Circle your answer):** | Yes/ No | |

Figure 1. The scenario of the vaccine conditions used in the study.

### Study variables

The dependent variable of this study was vaccine acceptance, defined as whether a participant would prefer to choose the vaccine under which scenario (Scenario A, Scenario B, or not vaccinate), given the combination of five attribute-specific parameters presented in each question. The independent variables were the five different attributes listed in **Table 1**; all of them were defined as nominal variables. Other covariates were all demographic variables, including generation, sex, location, education, religion, occupation, income and health status. For religion, participants were asked to respond to the question: "What is your religion?' with possible responses were: 'No, I do not have any religion,' 'Buddhism,' 'Catholicism,' 'Cao Dai,' 'Hoa Hao,' and 'Others'. If respondents chose 'No, I do not have any religion' the participant was classified as 'No,' otherwise 'Yes'.

Occupation was divided into: Students (currently studying in college or university and not working at any job), student and employee simultaneously (students who were studying and working part-time or working people while studying for a second degree), employed (employees with full-time job), unemployed (people on leave or have no work) and homemaker/retired/other (housewife, retiree, or people on military service). Income level was classified based on the average income of respondents, who chose the answer that corresponded to their income level, and then the amount was converted to USD. All of these covariates were used to identify the represented individuals for each class. If the value of a demographic variable was significant, it means that respondents in that class tend to have the corresponding characteristics. Except for income, which is a continuous variable, all other variables were classified as nominal.

### Statistical analysis

Data analysis in DCEs relies on random utility theory, where the utility of a product or service is expressed as a linear function weighted by attribute-specific parameters [26]. The utility of a systematic component ( $V_{njt}$) and a random component ( $\varepsilon_{njt}$) was determined using Equation 1 [27]:

$$U_{njt} = V_{njt} + \varepsilon_{njt} = X_{njt}\beta + \varepsilon_{njt} \quad (1)$$

in which $U_{njt}$ is the utility of that respondents $n$ derive from alternative $j$ on choice occasion $t$, $X_{njt}$ is an explanatory vector of attributes and $\beta$ denotes the coefficient vector of the corresponding preference parameter.

Both mixed logit and latent class models based on Equation 1 were used to analyze discrete choices [27]. This equation allows for the analysis of discrete choices using mixed logit and latent class models, which offer flexibility in handling preference heterogeneity and irrelevant alternatives [27]. In the present study, a latent class model categorized respondents based on their vaccine preferences, with the optimal number of classes determined using Akaike's information criterion (AIC) [28] and Bayesian information criterion (BIC) [29]:

$$\text{AIC} = 2k - 2\hat{l}$$
$$\text{BIC} = k \ln(n) - 2\hat{l}$$

where k represents the number of parameters in the model, $n$ denotes the sample size, and $\hat{l}$ is the maximized value of likelihood in the model. Latent GOLD Choice 6.0 (Statistical Innovations Inc., Arlington, USA) was used for clustering analysis. A mixed logit model in R for Windows v.4.3.2 (The R Foundation for Statistical Computing, USA) was employed to estimate respondents' willingness to vaccinate, considering both preference and scale heterogeneity in the analysis.

## Results

### Characteristic of participants

Among the 1,031 participants initially surveyed, 818 were deemed valid following exclusions, representing 79.3% of the initial sample. The characteristics of participants are presented in

**Table 2**. Of the total included participants, 60.4% were millennials, 52.1% were male, 80.1% resided in urban areas, 72.1% held a university degree or higher, and 66.1% identified as non-religious. The mean age was 26.5±6.1 years (**Table 2**).

Table 2. Participants' characteristics included in this study

| Characteristics | Millennials (n=494) | Gen Z (n=324) | Total (n=818) |
|---|---|---|---|
| | n (%) | n (%) | n (%) |
| Age (year), mean | 29.9±15.3 | 21.2±10.4 | 26.5±6.1 |
| Age (year), median (min-max) | 28 (24–42) | 21 (19–23) | 25 (19–42) |
| Sex | | | |
| Male | 304 (61.5) | 122 (37.7) | 426 (52.1) |
| Female | 190 (38.5) | 202 (62.3) | 392 (47.9) |
| Residence location | | | |
| Urban | 377 (76.3) | 278 (85.8) | 655 (80.1) |
| Rural | 117 (23.7) | 46 (14.2) | 163 (19.9) |
| Educational level | | | |
| Less than a university degree | 138 (27.9) | 90 (27.8) | 228 (27.9) |
| University degree or higher | 356 (72.1) | 234 (72.2) | 590 (72.1) |
| Religious status | | | |
| No | 338 (68.4) | 203 (62.7) | 541 (66.1) |
| Yes | 156 (31.6) | 121 (37.3) | 277 (33.9) |
| Occupational status | | | |
| Students | 107 (21.7) | 172 (53.1) | 279 (34.1) |
| Student and employee simultaneously | 32 (6.5) | 129 (39.8) | 161 (19.7) |
| Employed | 329 (66.6) | 17 (5.2) | 346 (42.3) |
| Unemployed | 16 (3.2) | 6 (1.9) | 22 (2.7) |
| Homemaker/retired/other | 10 (2.0) | 0 (0.0) | 10 (1.2) |
| Monthly income (USD) [a] | | | |
| Less than 176.7 | 48 (9.7) | 139 (42.9) | 187 (22.9) |
| 176.7 to less than 294.5 | 52 (10.5) | 48 (14.8) | 100 (12.2) |
| 294.5 to less than 412.2 | 103 (20.9) | 10 (3.1) | 113 (13.8) |
| 412.2 to less than 588.9 | 124 (25.1) | 10 (3.1) | 134 (16.4) |
| 588.9 to less than 1177.8 | 67 (13.6) | 6 (1.8) | 73 (8.9) |
| 1177.8 or more | 18 (3.6) | 1 (0.3) | 19 (2.3) |
| No income | 82 (16.6) | 110 (34.0) | 192 (23.5) |
| Health status | | | |
| Has comorbidities | 79 (16.0) | 52 (16.0) | 131 (16.0) |
| No comorbidities | 415 (84.0) | 272 (84.0) | 687 (84.0) |

[a] 1 USD equal to 25,471 VND based on exchange rate in May 2024

## Reasons for vaccine hesitancy

The predominant reason for vaccine hesitancy, reported by 517 participants (63.2%), was concern about potential vaccine risks. Other less frequently reported reasons included skepticism about vaccine efficacy (n=161, 19.7%), a perception of sufficient health to avoid infection (n=151, 18.5%), the belief that the vaccine was unnecessary (n=107, 13.1%), and mistrust in the vaccination capabilities of medical organizations (n=98, 12.0%). Additionally, 23 participants (2.8%) indicated other reasons for their hesitancy (**Figure 2**).

## Latent class analysis

Class refers to latent groups within the population used to represent preference heterogeneity [28]. The final latent class model identified was a four-class model with a minimum BIC value of 2214.1. A positive coefficient on levels indicates that participants preferred that feature when they considered accepting vaccination. A larger effect size indicates a stronger influence of that attribute level. Class 1 is the largest at 38% of participants (**Table 3**). Participants who belong to Class 1 preferred a vaccine with 90% effectiveness rather than 60% (coefficient (coef.) 0.76). They preferred to take a vaccine that has mild to moderate (coef. 1.01) or abnormal (coef. 0.57) side effects, even if these side effects are common, over a vaccine that can cause serious events even if very rare. For "Influential voices", participants preferred to receive advice from the Ministry of Health (coef. 1.16) and Doctors (coef. 0.75) for their vaccination decision rather than from famous people on social media. They also preferred to accept vaccination when receiving positive advice from family members/friends (coef. 0.97). Class 1 participants were less likely to choose the opt-out option (coef. 0.32) compared to Class 2 and Class 3, which means that if an

emerging infectious disease occurs in real life, they will accept vaccination, while participants in Classes 2 and 3 may refuse the vaccine (**Table 3**).

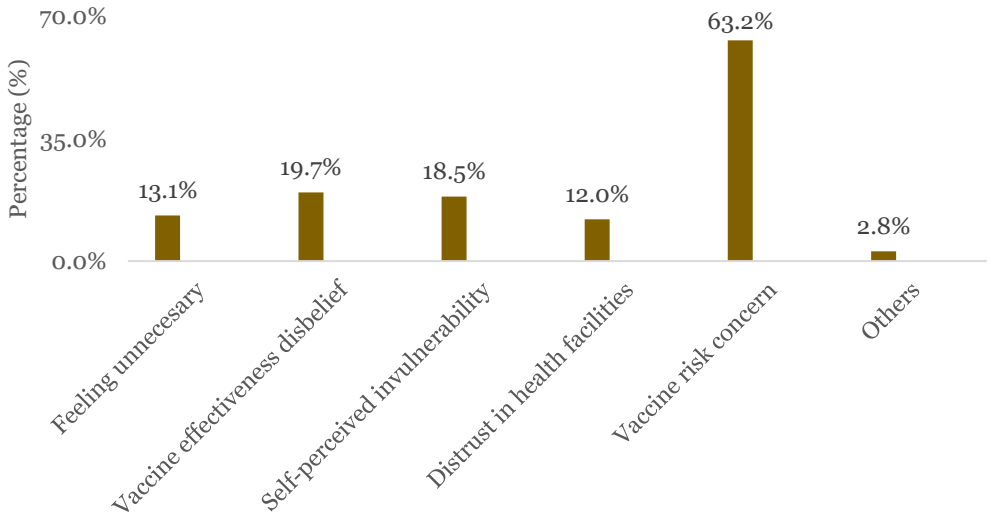



Figure 2. Reasons for vaccine hesitancy among the total respondents included in the study.

Additionally, 28% of participants belonged to Class 2, and respondents in this class tended to be religious people compared to Class 4 (reference class) as the coef. was a positive value (1.13) and was statistically significant. Their vaccination decisions were more strongly influenced by the Ministry of Health (coef. 3.10) and by doctors (coef. 1.91) than by advice from famous people. For the attribute "Trusted individuals", this class was more likely to be vaccinated when they received advice to get vaccinated from a family member/friend (coef. 2.36) or a religious leader (coef. 1.02). This group showed a greater inclination toward the "opt-out" option (negative coef. -2.81), which means people in this class tend to refuse vaccines in practice (**Table 3**).

Class 3, comprising 23% of participants, preferred attributes such as 90% vaccine effectiveness (1.07), mild to moderate side effects (2.26), and abnormal side effects (1.68) (**Table 3**). Advice from family or friends (0.61) and religious leaders (0.91) also motivated their decisions to accept the vaccine. Similar to Class 2, they tended to refuse vaccines (negative coef. -2.73) (**Table 3**).

Class 4, the smallest group (11% of the sample), preferred vaccines with high effectiveness (90%) (coef. 3.43) and valued advice from family or friends (coef. 1.47) (**Table 3**). They were more inclined to vaccinate when infection risks were associated with family members (coef. 3.77) or their local areas (coef. 3.74). Side effects, influential voices, and the "opt-out" option did not significantly impact their vaccination decisions compared to other classes (**Table 3**).

## Relative importance of attributes

Relative importance of the attributes was measured for each class, a measure of how important each attribute is, with the higher the relative importance coefficient of an attribute in a class, the more important that feature is for respondents in that class. In Class 1, influential voices were the most important attribute (0.25), followed by side effects (0.21), trusted individuals (0.21), vaccine effectiveness (0.16), and disease risks (0.10) (**Figure 3**). Class 2 also prioritized influential voices as the most important attribute (0.29), followed by trusted individuals (0.22), vaccine effectiveness (0.10), disease risks (0.07), and side effects (0.05). In Classes 3 and 4, influential voices were the least important attribute. Class 3 prioritized side effects (0.27), vaccine effectiveness (0.13), trusted individuals (0.11), and disease risks (0.10). Class 4 ranked side effects as the most important attribute (0.38), followed by disease risks (0.17), vaccine effectiveness (0.15), and trusted individuals (0.06) (**Figure 3**).

Table 3. Influence of each attribute in each class on respondents' preference for vaccination acceptance

| Variables | Class 1 [a] | | | Class 2 [a] | | | Class 3 [a] | | | Class 4 [a] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coef. | SE | Z-value | Coef. | SE | Z-value | Coef. | SE | Z-value | Coef. | SE | Z-value |
| Vaccine effectiveness | | | | | | | | | | | | |
| 60% (*ref*) | | | | | | | | | | | | |
| 90% | 0.76 | 0.08 | 9.05* | 1.06 | 0.16 | 6.64* | 1.07 | 0.15 | 6.94* | 3.43 | 0.47 | 7.25* |
| Side effects | | | | | | | | | | | | |
| Mild to moderate (very common) | 1.01 | 0.12 | 8.46* | 0.30 | 0.22 | 1.37 | 2.26 | 0.24 | 9.48* | 8.59 | 4.10 | 2.10 |
| Abnormal (less common) | 0.57 | 0.11 | 5.14* | 0.57 | 0.28 | 2.09 | 1.68 | 0.19 | 8.92* | 8.61 | 4.12 | 2.09 |
| Serious incident (very rare) (*ref*) | | | | | | | | | | | | |
| Influential voices | | | | | | | | | | | | |
| Ministry of Health | 1.16 | 0.12 | 9.43* | 3.10 | 0.34 | 9.17* | 0.44 | 0.19 | 2.27 | 0.93 | 0.40 | 2.33 |
| Doctors | 0.75 | 0.12 | 6.04* | 1.91 | 0.22 | 8.54* | 0.00 | 0.16 | -0.00 | 0.31 | 0.48 | 0.65 |
| Famous people on social media (*ref*) | | | | | | | | | | | | |
| Trusted individuals | | | | | | | | | | | | |
| A family member/friend advises you to take the vaccine | 0.97 | 0.11 | 8.58* | 2.36 | 0.36 | 6.63* | 0.61 | 0.17 | 3.60* | 1.47 | 0.41 | 3.61* |
| A family member/friend advises you not to take the vaccine | 0.26 | 0.12 | 2.16 | 0.31 | 0.20 | 1.58 | 0.68 | 0.27 | 2.51 | 0.34 | 0.39 | 0.89 |
| A religious leader advises you to take the vaccine | 0.40 | 0.12 | 3.25 | 1.02 | 0.21 | 4.92* | 0.91 | 0.26 | 3.50* | 0.10 | 0.38 | 0.26 |
| A religious leader advises you not to take the vaccine (*ref*) | | | | | | | | | | | | |
| Disease risks | | | | | | | | | | | | |
| Family members | 0.31 | 0.12 | 2.62 | 0.45 | 0.28 | 1.61 | 0.62 | 0.23 | 2.71 | 3.77 | 0.79 | 4.78* |
| Cases in your area of residence | 0.20 | 0.13 | 1.46 | 0.52 | 0.25 | 2.08 | 0.85 | 0.28 | 2.98 | 3.74 | 0.75 | 4.96* |
| Cases in a distant region of Vietnam | -0.17 | 0.14 | -1.19 | -0.21 | 0.31 | -0.69 | 0.40 | 0.30 | 1.35 | 2.37 | 0.79 | 3.00 |
| Cases in a neighboring country (*ref*) | | | | | | | | | | | | |
| Opt-out [b] | | | | | | | | | | | | |
| Yes (*ref*) | | | | | | | | | | | | |
| No | 0.32 | 0.09 | 3.69* | -2.81 | 0.30 | -9.24* | -2.73 | 0.39 | -7.07* | 4.52 | 1.42 | 3.19 |
| Generation | | | | | | | | | | | | |
| Millennials (*ref*) | | | | | | | | | | | | |
| Gen Z | 0.39 | 0.30 | 1.30 | 0.34 | 0.31 | 1.11 | 0.24 | 0.31 | 0.76 | . | . | . |
| Gender | | | | | | | | | | | | |
| Male | 0.42 | 0.30 | 1.38 | 0.56 | 0.30 | 1.86 | 0.47 | 0.31 | 1.52 | . | . | . |
| Female (*ref*) | | | | | | | | | | | | |
| Religious status | | | | | | | | | | | | |
| Yes | 0.09 | 0.29 | 0.29 | 1.13 | 0.33 | 3.45* | 0.12 | 0.31 | 0.38 | . | . | . |
| No (*ref*) | | | | | | | | | | | | |
| Health status | | | | | | | | | | | | |
| Has comorbidities | -0.16 | 0.35 | -0.45 | -0.82 | 0.42 | -1.97 | 0.09 | 0.36 | 0.26 | . | . | . |
| No comorbidities (*ref*) | | | | | | | | | | | | |
| Class size | 0.38 | | | 0.28 | | | 0.23 | | | 0.11 | | |

Ref: reference group; SE: standard errors

* Statistically significant at $p<0.05$

[a] The classes are latent groups within the population. Only Class 2 is identified as participants who tended to be religious. Other classes' characteristics were not significant statistics.

[b] Opting out is a continuous variable

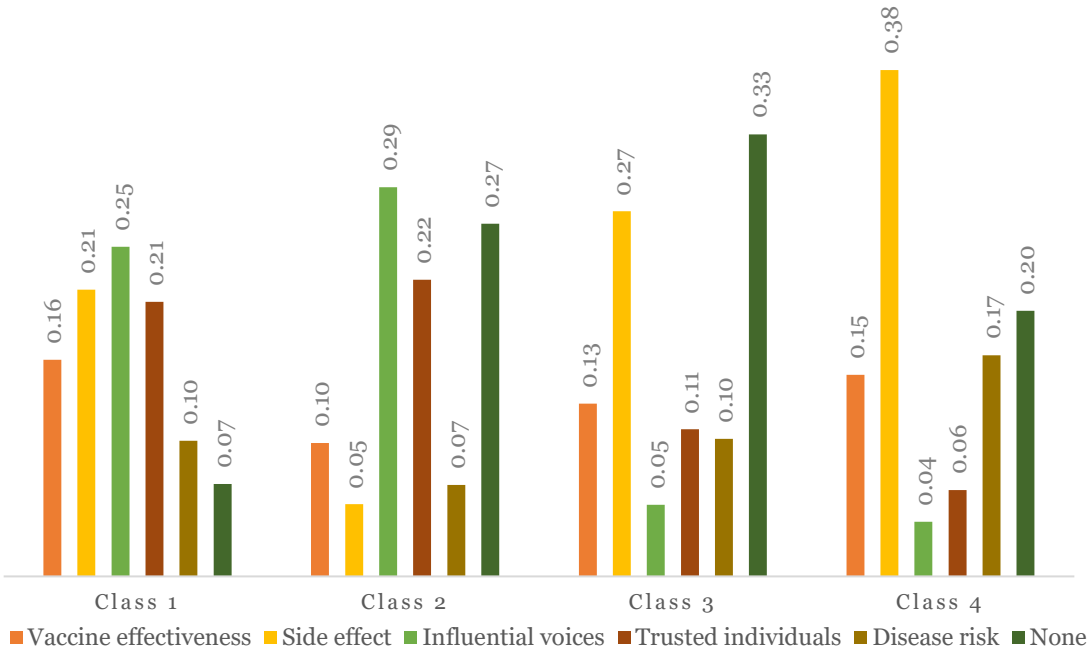



Figure 3. Relative importance of the attributes stratified by classes (a measure of how important each attribute is; the higher the relative importance coefficient of an attribute in a class, the more important that feature is for respondents in that class. The possible maximum relative important value is 1).

## Willingness to vaccinate

### *Overall probability of willingness to accept a newly developed vaccine*

The overall willingness to vaccinate was 76.3% (95%CI: 74.7–78.0) among participants. Among Millennials participants, it was 76.6% (95%CI: 74.5–78.7), slightly higher than Gen Z participants at 75.9% (95%CI: 73.3–78.6). Using a mixed logit model adjusting for generation, sex, location, religion, education, employment, income, and health conditions, the study estimated the likelihood of vaccination acceptance for both generations at 61.8% (95%CI: 60.8–62.9). Millennials showed a slightly higher acceptance rate of 62.4% (95%CI: 61.1–63.8) compared to Gen Z's 61.0% (95%CI: 59.4–62.5) (**Table 4**).

Table 4. Probability of willingness to vaccinate

| Variables | Frequency | Willingness to vaccinate in the study sample, % (95%CI) | Predicted probability of willingness to vaccinate in the population, % (95%CI) |
|---|---|---|---|
| Millennials | 494 | 76.6 (74.5–78.7) | 62.4 (61.1–63.8) |
| Gen Z | 324 | 75.9 (73.3–78.6) | 61.0 (59.4–62.5) |
| Total | 818 | 76.3 (74.7–78.0) | 61.8 (60.8–62.9) |

### *Predicted probability of willingness to accept a newly developed vaccine according to each attribute*

The predicted probability of vaccination willingness was highest at 90% vaccine effectiveness, with Millennials at 62.7%±12.3 and Gen Z at 61.6%±12.5. At 60% effectiveness, these probabilities decreased to 6.4%±8.8 and 5.3%±7.7, respectively. Mild to moderate side effects resulted in high vaccination probabilities: 44.2%±14.9 (Millennials) and 45.5%±15.5 (Gen Z), declining with more severe side effects. Ministry of Health recommendations had the highest acceptance probabilities: 56.3%±14.5 (Millennials) and 57.8%±14.7 (Gen Z), contrasting with low endorsements from celebrities (6.7%±9.5 and 6.2%±9.3, respectively). Positive advice from family and friends influenced willingness: 56.7%±21.6 (Millennials) and 55.4%±19.6 (Gen Z), while negative advice reduced it. High vaccination probabilities occurred when infection risks were from family members (58.3%±31.2 (Millennials) and 53.1%±30.4 (Gen Z) or local areas (32.1%±26.1 (Millennials) and 35.4%±26.3 (Gen Z) (**Figure 4**).

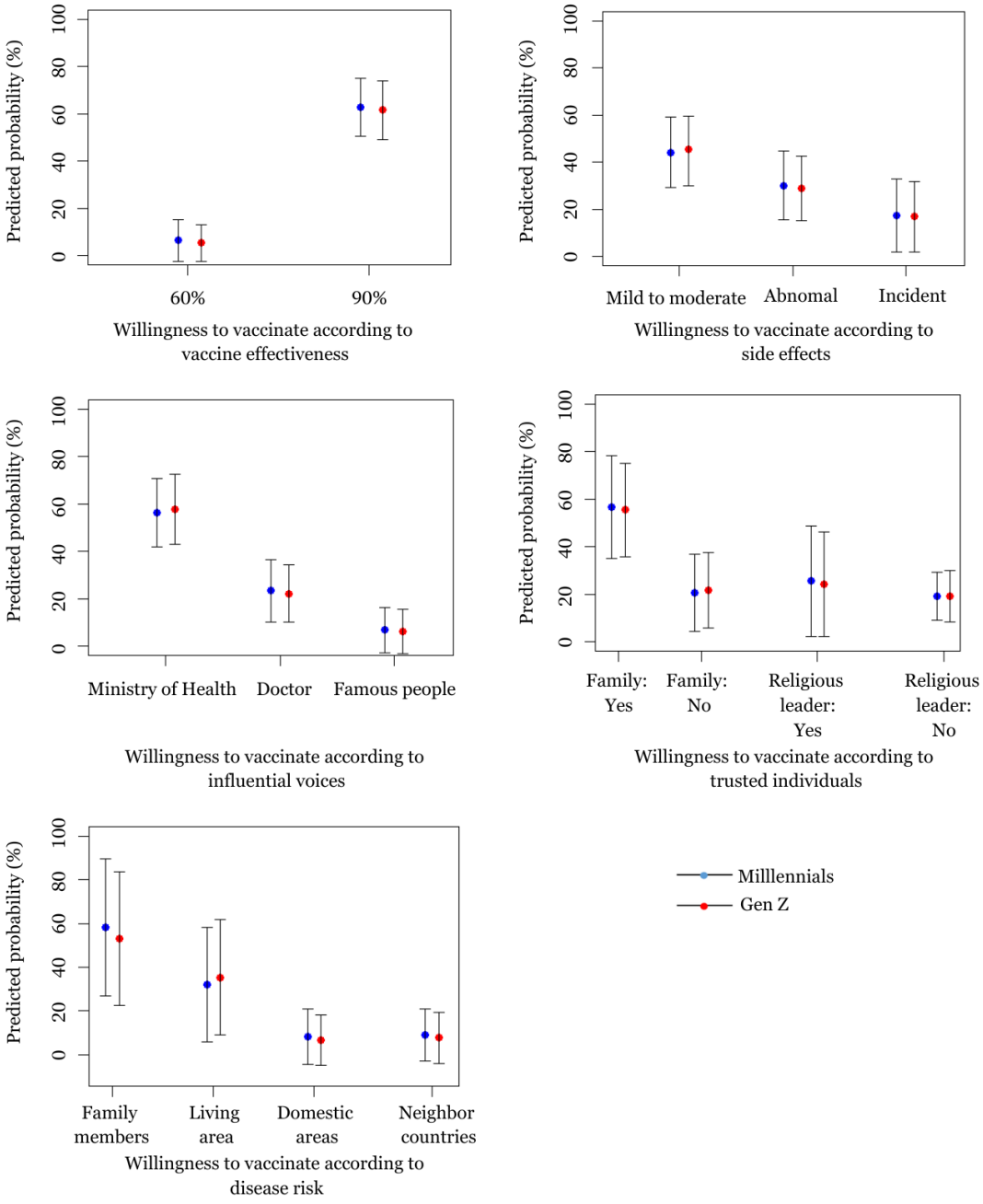



Figure 4. Probability of willingness to vaccinate based on five attributes.

## Discussion

The present study is a pioneering study in Vietnam aimed to investigate factors influencing willingness to accept new vaccines for preventing EIDs. Participants evaluated a hypothetical vaccine amid a scenario similar to the COVID-19 outbreak. The present study's relevance is highlighted by Vietnam's forthcoming introduction of new vaccines, such as Shingrix for Zona, Qdenga for dengue fever, and Gardasil 9 for cervical cancer, targeting individuals aged 27 to 45 years old.

Willingness to vaccinate among Millennials and Gen Z was 76.3% (95%CI: 74.7–78.0), higher than Tran *et al.* [30], reporting 65.4% willingness among those aged 16 to 24 for monkeypox vaccination. The discrepancy may be attributed to vaccine specificity: Tran *et al.* [30] studied a specific vaccine, contrasting with the hypothetical vaccine in the present study, potentially influencing participant decisions [30]. Furthermore, the overall predicted willingness to vaccinate among both Millennials and Gen Z was 61.8% (95%CI: 60.8–62.9), lower than the

71.5% reported in an international COVID-19 vaccine acceptability survey by Lazarus *et al.* [31]. Lazarus *et al.* noted that age correlated with higher acceptance rates, possibly explaining lower willingness observed here among individuals aged 19 to 42, notably those 19 to 22 [31].

The present study explored Millennials and Gen Z preferences for vaccine attributes influencing willingness to vaccinate, including effectiveness, side effects, influential voices, trusted individuals, and disease risks. The present findings highlighted a strong preference for highly effective vaccines across four presented classes, consistent with previous studies on vaccine preferences [2,16,32-34]. However, early epidemic stages may face limitations in vaccine availability and efficacy evidence [35]. Due to limited vaccine supplies, policymakers often have only one or two vaccine options to choose from in the early stages of an epidemic. For all countries, vaccine efficacy significantly influences vaccination preferences [35]. Therefore, it is crucial to declare the expected efficacy to enable the public to make informed decisions about whether or not to vaccinate. In the present study, vaccine side effects, whether mild to moderate or unusual, significantly influenced vaccination decisions, echoing previous findings [36-38].

In contrast to our findings, vaccine side effects were an attribute that did not influence vaccination decisions in the study in the Netherlands [17]. This discrepancy may be attributed to the selection of attribute levels, as respondents in the Netherlands study were informed that the likelihood of side effects was considered low, whereas we presented varying frequencies for different levels of side effects. A strategy to clearly explain the benefits of vaccines, emphasizing that they outweigh the risks of side effects, is needed to reassure the public about news related to vaccine side effects. Recommendations from influential figures, such as Ministry of Health officials or doctors, significantly shaped participants' decisions, reflecting earlier research [2,17]. Duong *et al.* also indicated that the acceptance rate of COVID-19 vaccination in Vietnam is highest when participants receive recommendations from the Government (89.1%) and doctors (85.9%) [39]. Cordero *et al.* showed that Filipinos turn to doctors and consider them the most appropriate individuals to recommend vaccines, compared to other healthcare professionals such as nurses [40]. Perhaps, like Filipinos, Vietnamese people have a high level of trust and respect for the Ministry of Health and physicians. Therefore, during the introduction of a new vaccine, authorities such as the Ministry of Health should actively promote vaccination and recommend that healthcare professionals, particularly doctors, encourage people to get vaccinated.

Our study showed that people in Class 2, who tend to be religious, are influenced by advice from religious leaders, but not significantly. This is similar to a study in rural communities in Bangladesh, where religious beliefs also had a negligible impact on COVID-19 vaccine uptake [41]. However, a 2021 study in Bangladesh demonstrated that Muslim residents were more hesitant about vaccination [42]. Perhaps because Buddhism is the main religion in Vietnam instead of Islam, our results reflect this difference. Future studies can explore the influence of other religious beliefs on people's vaccination decisions.

The present study illuminates the intricate factors influencing vaccine acceptance in Vietnam, emphasizing the need for tailored communication strategies and evidence-based policymaking to bolster vaccine uptake during epidemic responses. However, the study is constrained by several limitations. First, convenience sampling may restrict the generalizability of findings on vaccination preferences and willingness to vaccinate to the broader Vietnamese populace. Second, using hypothetical scenarios might not fully reflect actual vaccination behaviors during real epidemics, a common drawback in stated preference methodologies [43]. Furthermore, willingness to vaccinate may not always translate into actual vaccination uptake [44]. Third, the predominance of younger participants limits comparisons with older cohorts such as Gen X or Baby Boomers. Lastly, while the study examined preferences for specific attributes, it did not explore potential variations in factors such as vaccine cost, duration of immunity, access to vaccination sites, and incentives, which are also critical considerations.

Future research should broaden sample diversity to better elucidate vaccine acceptance across varied age groups and socioeconomic statuses. Integrating DCEs with revealed preference studies could overcome current study limitations. Expanding the demographic scope to include older cohorts such as Generation X and Baby Boomers would enable clearer comparisons of vaccination intentions across generations. Additionally, conducting surveys that cover a wider

range of attributes and scenarios derived from this study could provide more realistic insights into vaccination behaviors.

## Conclusion

This study used a DCE to explore public preferences for new vaccines targeting EIDs, revealing a 61.8% willingness to vaccinate among Generations Y and Z. Overall, Vietnamese Millennials and Generation Z preferred vaccination when the vaccine had 90% efficacy, mild to moderate side effects, endorsements from the Ministry of Health, positive recommendations from family and social networks, and high exposure risks from family members.

### Ethics approval

Protocol of the present study was reviewed and approved by Ethical Committee of Biomedical Research, Pham Ngoc Thach University of Medicine, Ho Chi Minh, Vietnam (Approval number: 1084/TDHYKPNT-HDDD).

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### Competing interests

All the authors declare that there are no conflicts of interest.

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### Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

### Declaration of artificial intelligence use

We hereby confirm that no artificial intelligence (AI) tools or methodologies were utilized at any stage of this study, including during data collection, analysis, visualization, or manuscript preparation. All work presented in this study was conducted manually by the authors without the assistance of AI-based tools or systems.

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