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Kimberly Bonner, Sandra Chyderiotis, Jonathan Sicsic, Judith E. Mueller, Angela Ulrich, et al.. What motivates adults to accept influenza vaccine? An assessment of incentives, ease of access, messaging, and sources of information using a discrete choice experiment. SSM - Population Health, 2023, 22, pp.101384. 10.1016/j.ssmph.2023.101384 . hal-04165930

HAL Id: hal-04165930

<https://ehesp.hal.science/hal-04165930>

Submitted on 19 Jul 2023

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What motivates adults to accept influenza vaccine? An assessment of incentives, ease of access, messaging, and sources of information using a discrete choice experiment

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ARTICLE INFO

Keywords:

Influenza vaccine
Discrete choice experiment
Vaccine confidence
Vaccine demand
Adults

ABSTRACT

Seasonal influenza vaccination rates remain low, and contribute to preventable influenza cases, hospitalizations, and deaths in the US. While numerous interventions have been implemented to increase vaccine uptake, there is a need to determine which interventions contribute most to vaccine willingness, particularly among age groups with vaccination rates that have plateaued at suboptimal levels. This study aimed to quantify the relative effect of multiple interventions on vaccine willingness to receive influenza vaccine in three age groups using a series of hypothetical situations with different behavioral interventions.

We assessed the relative impact of four categories of interventions: source of vaccine messages, type of vaccination messages, vaccination incentives, and ease of vaccine access using a discrete choice experiment. Within each category, we investigated the role of four different attributes to measure their relative contribution to willingness to be vaccinated by removing one option from each of the intervention categories. Among the 1,763 Minnesota residents who volunteered for our study, participants expressed vaccine willingness in over 80% of the scenarios presented. Easy access to drop-in vaccination sites had the greatest impact on vaccine willingness in all age groups. Among the younger age group, small financial incentives also contributed to high vaccine willingness.

Our results suggest that public health programs and vaccination campaigns may improve their chances of successfully increasing vaccine willingness if they offer interventions preferred by adults, including facilitating convenient access to vaccination and offering small monetary incentives, particularly for young adults.

1. Introduction

Reducing the morbidity and mortality caused by influenza remains a public health priority. Influenza and is among the leading causes of death in the United States (US), and it accounts for at least 300,000 hospitalizations in the US each year (CDC, 2022). Since 2010 the US Centers for Disease Control and Prevention (CDC) Advisory Committee on Immunization Practices (ACIP) has recommended annual influenza

vaccination for all individuals aged six months and older. Despite this universal vaccination recommendation, seasonal influenza vaccination rates in the US are not on track to meet the 70% influenza vaccine coverage target by 2030 (U.S. Department of Health and Human Services Office of Disease Prevention and Health Promotion). Annual influenza vaccination coverage for adults has never surpassed 40% since vaccine introduction, and low vaccination levels persist despite the COVID-19 pandemic (CDC, 2018; 2021b; Williams WW & O'Halloran,

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<https://doi.org/10.1016/j.ssmph.2023.101384>

Received 3 November 2022; Received in revised form 10 March 2023; Accepted 13 March 2023

Available online 14 March 2023

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2017).

Low influenza vaccination uptake contributed to an estimated 785,000 excess cases and up to 105,000 influenza-associated hospitalizations annually that could have been prevented by vaccination (CDC, 2020; Hughes et al., 2020). These cases add strain on hospital systems (Putri, Muscatello, Stockwell, & Newall, 2018) and result in disproportionate morbidity and mortality to pregnant people (Thompson et al., 2019) and people with chronic health conditions (Bekkat-Berkani et al., 2017; Colquhoun, Nicholson, Botha, & Raymond, 1997). Influenza vaccination coverage was lowest among young adults compared to older age groups: 37.7% for adults 18–49 years of age, 54.2% for adults 50–64 years of age and 75.2% for adults aged 65 years and above in the 2020–2021 influenza season (CDC, 2018; 2021a). Improving vaccine uptake benefits both individuals by protecting them directly from influenza and communities by reducing influenza transmission (Huang, Lin, Sheng, & Wang, 2021).

Understanding the contribution of behavioral and social factors to vaccination intent and willingness to receive an influenza vaccine are critical to designing interventions that leverage these drivers to increase vaccination uptake. The World Health Organization (WHO) developed the Behavioral and Social Drivers of Vaccination (BeSD) framework to identify modifiable parameters that contribute to the likelihood that an individual will get vaccinated (N. T. Brewer et al., 2007; WHO, 2020) (N. Brewer, 2021; N. T. Brewer, Chapman, Rothman, Leask, & Kempe, 2017). The BeSD framework identifies three primary and modifiable elements that contribute to vaccination uptake: 1) *what people think and feel*, which includes cognitive and emotional responses to vaccines and vaccine-preventable diseases; 2) *social processes*, including social norms about vaccination and recommendations to be vaccinated; and 3) *practical issues*, including access barriers and other experiences encountered when trying to get vaccinated (WHO, 2020).

While several systematic reviews have examined vaccination preferences and barriers among populations at higher risk of influenza and severe outcomes via surveys (Daniels, Juarbe, Rangel-Lugo, Moreno-John, & Perez-Stable, 2004; Nagata et al., 2013; Santibanez & Kennedy, 2016), less effort has focused on understanding what motivates adults in different age groups to receive influenza vaccine. Research in this area is important because vaccination rates differ significantly by age and while older adults have the highest risk (CDC, 2020), younger adults have the lowest overall influenza vaccination rates. In a systematic review of reasons for not receiving influenza vaccine, young adults indicated that they that they were not at risk of serious illness and the influenza vaccination recommendations did not apply to them (Quinn et al., 2018; Quinn, Jamison, An, Hancock, & Freimuth, 2019). Facilitators of influenza vaccination include health care provider recommendation and the convenience of vaccination (Nowak, Cacciatore, & Len-Rios, 2018; Nowak, Sheedy, Bursley, Smith, & Basket, 2015; Quinn et al., 2019).

Standard survey designs typically assess the role of each facilitator (here defined as a parameter) independently of other factors. In contrast, DCEs are structured to quantify the relative contribution of a given parameter amidst multiple other parameters in a decision on willingness to be vaccinated. The process of vaccination decision-making itself changes over the life-course (Strough, Karns, & Schlosnagle, 2011), with adults aged 18–40 years more tolerant to more choices and weighing of choices compared to adults aged 60 years and above (Besedes, Deck, Sarangi, & Shor, 2012). This indicates the value of understanding how adults of various ages weigh various parameters to arrive at their vaccination decision.

Our overall objective is to determine what factors most influence adults' decisions to receive the influenza vaccine. To identify which parameters most influence adults' decisions when considering multiple parameters simultaneously, we used a discrete choice experiment (DCE) design. We assessed the unconditional preference to receive an influenza vaccine, given the attributes and parameters presented (here defined as vaccine willingness). Next, we assessed the preferred parameters within

each attribute by estimating the partial utility and then estimated the preferred attributes by age category (18–40 years; 41–64 years; and 65 years and above). Identifying the preferred parameters and attributes that influence vaccine willingness can inform tailored interventions to optimize public health interventions designed to increase influenza vaccine uptake across the lifespan.

2. Materials and methods

2.1. Survey description

We conducted a DCE survey from August 22nd–31st, 2019 at the University of Minnesota (UMN) Driven to Discover Research Facility at the Minnesota State Fair. Eligible participants were aged 18 years and above, able to read and speak English, and were residents of the state of Minnesota. A convenience sample was obtained by recruiting volunteers in person at the study site. Study staff screened participants for eligibility, described the study, and conducted informed consent. Participants completed a self-administered, anonymous survey using the Qualtrics platform ("Qualtrics," 2020) on a tablet. The survey took approximately 10 min for participants to complete. All participants received either a drawstring bag or a mini flashlight to thank them for their time. This study received ethical approval from the UMN Institutional Review Board (IRB).

The survey consisted of 25 questions, grouped into three sections: demographic characteristics, vaccination history and opinions, and the DCE questions (Appendix 1). The demographic questions included age, sex, zip code, race and ethnicity, highest level of education, and whether any individuals at a higher risk of influenza morbidity and mortality lived with the participant. The vaccination history questions asked participants about their frequency of influenza vaccination in the past ten years, their reasons for receiving or not receiving an influenza vaccination in years when they received or did not receive a vaccine, and if the influenza vaccine was required at their place of employment. The DCE section included information on influenza and influenza vaccination to provide context to the subsequent nine paired choice sets, each followed by the same question "What would you prefer to do?" (example in Fig. 1).

2.2. Description of the discrete choice experiment

We developed our pairwise DCE with opt-out in accordance with recent guidelines and recommendations on DCE development (Bridges et al., 2011; Hauber et al., 2016). This DCE presented each participant with two scenarios side-by-side, each describing a different situation under which influenza vaccine could be offered. Each pair of situations (choice set) was followed by the same question about whether the participant would prefer to receive an influenza vaccine given the parameters listed in Situation A, in Situation B, or opt out from receiving a vaccine at all. Each situation described a specific parameter for each of four categories (attributes) relevant to influenza vaccination, with the combination of the attributes differing by situation.

To define the attributes and levels presented to participants, we used the behavioral and social constructs underlying the BeSD framework (N. T. Brewer et al., 2017) and undertook an extensive literature review of other DCEs on adult vaccination to identify four modifiable attributes in the behavioral and social domains that could promote vaccine willingness (de Bekker-Grob et al., 2010; de Bekker-Grob et al., 2018; Determann et al., 2014; Determann et al., 2016; Eshun-Wilson et al., 2021; Ledent et al., 2019; Michaels-Igbokwe, MacDonald, & Currie, 2017; Poulos, 2016; Seanehia et al., 2017; Shono & Kondo, 2014; Verelst, Kessels, Delva, Beutels, & Willem, 2019) (Table 1, see Appendix 2 for details). Based on this research, we selected the specific parameters we presented to participants from the wide range of possible parameters pragmatically via discussion among co-authors and colleagues. We aimed to balance presenting real-world interventions that have been

For the next set of questions, please read and remember the following information.

IMPORTANT INFLUENZA (FLU) FACTS

- The flu is a respiratory illness that can cause fever, body aches, sore throat, and fatigue.
- During the last flu season in the US, **49 million people got the flu, 960,000 were hospitalized, and 80,000 people died from the flu.**

IMPORTANT INFLUENZA (FLU) VACCINE FACTS

- Everyone aged six months and older is recommend to get the flu vaccine each year.
- Some flu vaccines are given as a shot in the arm and some are sprayed into the nose.
- During the last flu season in the US, **the flu vaccine prevented 7 million flu cases, 109,000 hospitalizations, and 8,000 deaths from the flu.**
- Minor side effects from the vaccine are common. Only 1 out of 1 million people experience a side effect requiring hospitalization.

Situation A
<ul style="list-style-type: none"> ▪ You find out from a clinician: <i>"Getting the vaccine reduces your chances of getting the flu, but there is still a possibility of getting the flu, even with the vaccine."</i> ▪ You know that you can receive the vaccine during the day and on evenings and weekends. ▪ You also know that you can get the flu vaccine somewhere you don't usually go and you <u>need</u> an appointment.
Situation B
<ul style="list-style-type: none"> ▪ You find out from a trusted family member or friend: <i>"Getting the flu vaccine protects vulnerable people and you from the flu."</i> ▪ You know that you can get a \$5 gift card for getting the flu vaccine. ▪ You also know that you can get the flu vaccine somewhere you don't usually go and you <u>need</u> an appointment.

What would you prefer to do?

Get the flu vaccine in Situation A

Get the flu vaccine in Situation B

I would not get the flu vaccine in either situation

Fig. 1. Framing scenario and example of a Discrete Choice Experiment choice set.

implemented in the past with theoretical options that could be made available relatively easily on a large scale. Given that access issues persist as the most common barrier identified in the influenza vaccination literature (Schmid, Rauber, Betsch, Lidolt, & Denker, 2017), we sought to explore multiple ways in which access could present barriers or facilitate vaccination. For example, whether the commitment device of an appointment, whether the convenience of the vaccination site, or the combination of these factors, improved vaccination willingness compared to neither access option. The DCE design relies upon random utility theory to draw valid inference. We assume that utility is defined as the function of observed and unobserved components of a particular decision, that individuals seek to maximize their utility when making decisions, and that the key elements of a given decision are represented in attributes and parameters presented in the DCE {Lancsar, 2008

Table 1

Attributes and parameters presented to participants in the Discrete Choice Experiment (DCE).

Attribute	Attribute-specific parameters
Source	1 A clinician 2 A trusted family member or friend 3 A flyer or a billboard (ref) Social media
Message	1 Getting the flu vaccine protects vulnerable people and you from the flu. 2 Your friends are getting the flu vaccine. 3 If everyone got the flu vaccine, it would prevent 50% of flu cases and flu deaths. (ref) Getting the vaccine reduces your chances of getting the flu, but there is still a possibility of getting the flu even with the vaccine.
Incentive	1 You can get a \$5 gift card for getting the flu vaccine. 2 You can receive a reminder text message/phone call to get the flu vaccine this year. 3 You can receive the vaccine during the day and on evenings and weekends. (ref) You can receive free transportation to a vaccination site.
Access	1 Somewhere you go daily and you don't need an appointment. 2 Somewhere you go daily but you need an appointment. 3 Somewhere you don't usually go but you don't need an appointment. (ref) Somewhere you don't usually go and you need an appointment.

Ref = reference level in statistical analyses; each parameter estimate in the attribute was presented in comparison to the reference level estimate.

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Two rounds of pilot testing occurred in July 2019 with 27 participants using a think-aloud exercise. The purpose of this pilot testing was to identify confusing language, explore participant understanding of the discrete choice experiment questions, and evaluate formatting preferences for the DCE questions.

The first choice set of the randomly ordered set of eight was duplicated and presented as the ninth choice set for use as a consistency check. The responses to the first scenario was not analyzed; the last question was used for the main analyses. The experimental design was determined using the SAS 9.4 (Optex) for a fractional factorial design and R (OptFederov) for blocking (Brett-Major et al., 2015; Inc, 2013; Team, 2019; Wheeler, 2004).

2.3. Measures

Our primary outcome was vaccine willingness, categorized as accepting influenza vaccine based on Situation A, accepting influenza vaccine based on Situation B, or opting-out of receiving influenza vaccine. These three outcome categories were retained to assess relative contribution of attributes and attribute-specific parameters to vaccine willingness (Objectives 2 & 3). To assess vaccine willingness (Objective 1), this three-category outcome variable was collapsed into a binary variable (any stated willingness to vaccinate, no stated willingness for either scenario).

Sex and race/ethnicity were included as covariates in the adjusted analyses. Participants were provided the following options: "Males", "Female", "Other", or "Prefer not to say". Race and ethnicity were determined by self-report, using a survey question proposed by the US Census that asks participants, "What is your race and ethnicity? Check all that apply". Participants could select anywhere from one to all categories in their response. Possible responses included, "American Indian or Alaskan Native", "Asian", "Black or African-American", "Hispanic, Latino, or Spanish", "Middle Eastern or North African", "Native Hawaiian or Other Pacific Islander", "White", "Prefer not to say", "Other" or any combination of these categories. The responses to these questions were collapsed into three categories: "Non-Hispanic white" if participants selected only the category "White"; "All other racial/ethnic groups" if participants selected any other category or a category additional to "White"; and "Prefer not to say" if the participant selected

“Prefer not to say”.

2.4. Statistical analyses

We tabulated the number and proportion of participants with each individual-level covariate and reported the results overall and stratified by age group: 18–40, 41–64, and 65 years and above.

We reported influenza vaccine willingness (defined as a stated willingness to receive an influenza vaccine in either situation A or B, compared to choosing not to receive an influenza vaccine in either situation) among all participants and for each age group for Objective 1. We ran random intercept logit models accounting for individual-level heterogeneity for each of the eight responses per individual and calculated the predicted probability of expressing vaccine willingness, and stratified by age group. We estimated 99% standard errors using the delta method to account for the multiple comparisons. Models were adjusted for sex and race/ethnicity.

To assess the relative importance of each parameter, we first calculated the partial utility of each parameter by using mixed multinomial logistic regression models (40), with random effects using 500 Halton draws to account for individual-level and parameter-specific heterogeneity (Objective 2). The outcome variable was vaccination decision in each given choice set (Situation A, Situation B, or no vaccination). Our independent variables were the specific parameters displayed for each of the four attributes “Source of message”, “Vaccination messages”, “Incentives” and “Access” (Table 1) and were assessed for each age category: age 18–40; age 41–64; and age 65 years and above, with sex and race/ethnicity included as covariates.

Following Lancsar and colleagues (Lancsar, 2007), we then assessed the relative importance of each attribute by calculating the partial log likelihood of each attribute to the outcome of influenza vaccine willingness. For each age group, we ran four mixed multinomial logistic regression models with random effects for each attribute. We used the log-likelihood to calculate the sum of the difference in log-likelihood between the full model and each model missing one of the attributes. To calculate the relative effect of each attribute, we divided the difference in log-likelihood between the missing attribute model and full model by the sum of all the differences and multiplied by 100.

To estimate the predicted probability of the difference between each attribute-specific parameter and the reference values for each of the attributes, we ran a mixed multinomial logistic regression for each age group, including sex and race/ethnicity as covariates, and then calculated the predicted probability of expressing vaccine willingness in a given choice set, holding all other attributes at their reference value and standardizing the covariates at their means (Muller & MacLehose, 2014). We plotted these predicted probabilities of vaccine willingness for each parameter and each age group (Objective 3).

2.5. Sensitivity analyses

We undertook an assessment of data quality by conducting three sensitivity analyses in accordance with standard practices for DCE (Bech, Kjaer, & Lauridsen, 2011; Coast et al., 2012; F. Johnson, Y, & Reed, 2018; Quaife, Terris-Prestholt, Di Tanna, & Vickerman, 2018; Rakotonarivo, Schaafsma, & Hockley, 2016; Veldwijk et al., 2016). These tests included defining subgroups of respondents based on: 1) *duration*: completed the survey in 5 min or longer; 2) *concordance*: answered the two duplicates DCE questions consistently; and 3) *non-straightliners*: varied their survey responses (e.g. excluding those who exclusively selected Situation A or exclusively selected Situation B for every choice set). To assess selection bias, we defined two subsets of respondents by influenza vaccination history, with a “never vaccinated” and an “ever vaccinated subset. We ran a random intercept logit model accounting for individual-level heterogeneity using the full analytic dataset and including sex, race/ethnicity as covariates. We calculated the predicted probability of vaccine willingness for the average individual and standardized the covariates at their means. We estimated

standard errors using the delta method and compared the predicted probabilities and 95% CIs between the full sample of participants to the subset of participants that had passed a sensitivity test to compare them for differences in the predicted probabilities. In addition, we evaluated the partial utility of each parameter by using mixed multinomial logistic regression models with each subgroup identified in the sensitivity analysis. Stata 16 was used for all analyses (StataCorp, 2019).

3. Results

Overall, 1,803 participants enrolled in the study. Nine participants who did not complete the demographics questions and 31 participants who did not complete the DCE questions were excluded from the analysis. The resulting analytic dataset consisted of 1,763 participants; 611 participants aged 18–40 years, 628 participants aged 41–64 years, and 524 participants aged 65 years and above (Table 2). Female respondents constituted between 58 and 65% of each age category. The proportion of respondents indicating All other race/ethnicity was 22% among those 18–40 years, 13% among those 41–64 years, and 6% among those 65 years and above. The majority of respondents reported living inside the seven-county Minneapolis-St Paul metro area (ranging from 76% to 86%) (Table 2). At least 88% of participants in each age group reported that they had ever received an influenza vaccination. Responses to behavioral questions indicated that at least 58% of participants in each age group strongly agreed with the statement “It is important to get the flu vaccine” (Table S1).

Table 2

Demographic characteristics of the 1,763 study participants who completed the Discrete Choice Experiment on influenza vaccine willingness by age group.

		Age group			p-value
		18–40 years	41–64 years	65+ years	
		N = 611	N = 628	N = 524	
Sex	Male	233 (38%)	216 (34%)	216 (41%)	0.051
	Female	370 (61%)	409 (65%)	306 (58%)	
	Other	5 (1%)	1 (0%)	0 (0%)	
Age	Prefer not to say	3 (0%)	2 (0%)	2 (0%)	<0.001
	in years (Mean	28 (7)	54 (7)	70 (5)	
	(SD))				
Race, ethnicity	White	467 (76%)	536 (85%)	493 (94%)	<0.001
	All other race/ ethnicity	132 (22%)	84 (13%)	30 (6%)	
	Prefer not to say	12 (2%)	8 (1%)	1 (0%)	
Education	Some high school	13 (2%)	4 (1%)	1 (0%)	<0.001
	High school diploma or GED	76 (12%)	28 (4%)	45 (9%)	
	Associate's degree	49 (8%)	50 (8%)	48 (9%)	
	Some college	116 (19%)	77 (12%)	95 (18%)	
	Bachelor's degree	213 (35%)	205 (33%)	154 (29%)	
	Graduate or professional degree	142 (23%)	254 (40%)	174 (33%)	
Seven County Metro Area	Other	2 (0%)	10 (2%)	7 (1%)	<0.001
	Outside 7 metro counties	86 (14%)	97 (15%)	125 (24%)	
	Within 7 metro counties	525 (86%)	531 (85%)	399 (76%)	
Ever had influenza vaccine lifetime	Yes	556 (91%)	550 (88%)	484 (92%)	0.014
	No, never	47 (8%)	74 (12%)	38 (7%)	
	I do not know	8 (1%)	4 (1%)	2 (0%)	

Note: p-value obtained from Pearson's chi-squared tests.

3.1. Objective 1. difference in vaccinate willingness by age group

Influenza vaccine willingness ranged between 81.9% (99% CI 81.2–82.6) for 41–64 year olds to 84.0% (99% CI 81.6–86.5%) among 18–40 year olds in adjusted analyses (Table 3).

3.2. Objective 2. Association between attributes and vaccine willingness

Messages from a *clinician* or *trusted family member or friend* were associated with a larger magnitude of association with vaccine willingness compared to the reference source of *social media* for each age group (Table 4). The message highlighting that vaccination is a social norm, “*Your friends are getting the flu vaccine*,” was associated with significantly lower vaccine willingness, compared to the reference message “*Getting the vaccine reduces your chances of getting the flu, but there is still a possibility of getting the flu even with the vaccine*” for each age group. Incentives of “*\$5 gift cards*” had the greatest magnitude of association with vaccine willingness for the 18–40 and 41–64 age group compared to “*free transportation to a vaccination site*”. In addition, *text message reminders and phone calls* reported a modest, but significant, association with vaccine willingness for each age group. The access options that did not require an appointment were significantly associated with vaccination intent, compared to “*somewhere you don’t usually go and you need an appointment*” for each age group. Although the “*\$5 gift card*” incentive and the option to receive the vaccination without appointment had the highest impact on vaccine willingness, they also displayed the highest levels of preference heterogeneity.

For all age groups, the Access attribute ranked first and accounted for 69%–78% of the relative effect of the change in log-likelihood (Table S3).

3.3. Objective 3. Predicted probability of influenza vaccination by parameter and age group

Fig. 2 displays predicted probability of vaccine willingness, compared to the reference parameter and adjusted for covariates for each age group. For the source of messages, vaccine willingness ranged from 74.1% among 41–64 year olds for a “*flyer or billboard*” to 89.3% among 18–40-year-old adults for messages from a “*clinician*.” This means that 89.3% of 18–40 year olds were willing to receive an influenza vaccine when it was recommended by a clinician, regardless of the other attributes presented to them in the choice sets. For the Message attribute, the mean predicted probabilities for vaccine willingness ranged from 75.2% among 41–64 year olds with the message “*Your friends are getting the vaccine*” to 85.7% among 18–40 year olds with the message “*Getting the flu vaccine protects vulnerable people and you from the flu*.” This means that 85.7% of 18–40 year olds were willing to receive an influenza vaccine when they heard this message, regardless of the other attributes presented to them in the choice sets.

When offered a \$5 incentive, 99.2% of 18–40 year olds, 87.5% of 41–64 year old, and 83.9% of those 65 years and above stated their willingness to receive an influenza vaccine, regardless of the other attributes presented to them in the choice sets. For all three age groups,

Table 3

Predicted percent of choosing to receive a vaccine (vs not receive a vaccine) among respondents aged 18–40, 41–64, and 65 years and above.

	Predicted percent unadjusted (%) 99% CI	Predicted percent adjusted (%) 99% CI
Overall	82.6 (82.0–83.3)	82.7 (82.0–83.4)
18–40 years	83.7 (81.5–85.8)	84.0 (81.6–86.5)
41–64 years	81.9 (81.2–82.6)	81.9 (81.2–82.6)
65 years and above	82.8 (81.4–84.2)	83.0 (81.2–84.8)

^aPanel logit model with random intercept for individual-level clustering in responses, adjusted for sex and race/ethnicity.

participants preferred receiving the influenza vaccine in places they went daily without needing an appointment.

3.4. Sensitivity Analyses

Three sensitivity analyses of Objective 1 restricted each analytic dataset to the subset of participants who passed one of the following sensitivity tests for duration, concordance, or non-straightliners. The predicted probability of influenza vaccine willingness in these sensitivity subsets did not result in substantial changes in the predicted probability of vaccine willingness, compared to the primary analysis (Table S2). Substantial differences were not detected in the significance of the associations between parameters and vaccine willingness (Table S4).

4. Discussion

In this study, we examined the role of sixteen parameters to understand how the source of messages, the content of messages, incentives, and ease of access could influence stated willingness to receive an influenza vaccination among adults in three age groups. We chose to examine potentially modifiable interventions that could be designed to more effectively promote influenza vaccination.

After presenting a series of “flu facts” and presenting two vaccination options (Fig. 1), we found that respondents reported influenza vaccine willingness in over 80% of the scenarios presented, and intent did not vary significantly by age group. An option to receive an influenza vaccination without an appointment was the greatest contributor to vaccine willingness. A small financial incentive was the second largest contributor to high vaccine willingness among adults 18–40 years. These attributes also generated the highest levels of preference heterogeneity. While the source of vaccine recommendation was not a leading driver of influenza vaccine willingness, participants’ responses suggested recommendations from clinicians were more influential than other sources, consistent with previous research on the positive effect of provider recommendations on vaccination uptake (Thomas & Lorenzetti, 2018).

By employing the DCE methodology, this study builds upon the findings of systematic reviews (N. T. Brewer et al., 2017; Schmid et al., 2017; Wu et al., 2017) to generate rankings between and among interventions that target access, vaccination messages, the source of messages, and incentives, as it enabled respondents to consider these parameters in concert with one another, rather than individually. This study identified consistent attributes rankings across age groups between intervention categories and among interventions. This consistency made the few exceptions more notable, particularly the strong preference for small financial incentives in the 18–40 years group compared to free transportation. In comparison, a previous study reported preferences for small financial incentives in elderly populations (Yu, Yi, Chng, Yoong, & Cook, 2020). Moreover, recent studies showed that, despite their costs, financial incentives had significant impacts on actual Covid-19 vaccination uptake (Campos-Mercade et al., 2021; Sprengholz, Henkel, & Betsch, 2022). Vaccination messaging was ranked as the lowest (in terms of impact on vaccine willingness) out of all attributes presented. We did not specify any interactions between message content and messenger *a priori*, although a systematic review of behavioral interventions suggests that optimal combinations of message and messenger could reduce vaccine hesitancy (Renosa et al., 2021). We found only a modest variation in the effect of various messaging interventions, which were structured to address constructs of complacency, social responsibility and social conformism (Betsch et al., 2018). However, no message targeting confidence in vaccine safety was included, as previous studies suggested that this point is of minor importance for flu and COVID-19 vaccines in the US (Betsch et al., 2018; Betsch, Korn, & Holtmann, 2015; Moirangthem et al., 2022). However, other studies have found messaging has contributed a modest, but

Table 4

Association between attribute-specific parameters and influenza vaccine willingness, compared to the reference parameter for each attribute among a convenience sample of Minnesota adults.

VARIABLES	All		18-40		41-64		65+	
	Coefficient (se)	Random coef. sd (se)	Coefficient (se)	Random coef. sd (se)	Coefficient (se)	Random coef. sd (se)	Coefficient (se)	Random coef. sd (se)
Source								
Social media (Ref)			Ref	Ref	Ref	Ref	Ref	Ref
A clinician	0.77** (0.07)	0.03 (0.21)	0.61** (0.12)	-0.21 (0.21)	0.85** (0.14)	0.15 (0.21)	1.08** (0.14)	-0.36 (0.28)
A trusted family member/friend	0.60** (0.07)	0.07 (0.11)	0.54** (0.12)	-0.05 (0.23)	0.59** (0.13)	0.16 (0.16)	0.82** (0.14)	0.0 (0.20)
A flyer or billboard	0.33** (0.08)	-0.10 (0.18)	0.35** (0.13)	0.26 (0.29)	0.29* (0.14)	0.04 (0.38)	0.32* (0.15)	-0.08 (0.25)
Message								
Getting the vaccine reduces your chances of getting the flu, but there is still a possibility of getting the flu even with the vaccine. (Ref)			Ref	Ref	Ref	Ref	Ref	Ref
Getting the flu vaccine protects vulnerable people and you from the flu.	0.15 (0.08)	-0.71** (0.12)	0.19 (0.15)	0.98** (0.18)	0.10 (0.15)	-0.78** (0.20)	0.23 (0.15)	-0.28 (0.40)
Your friends are getting the flu vaccine.	-0.72** (0.09)	0.03 (0.66)	-0.80** (0.16)	-0.42 (0.34)	-0.81** (0.18)	-1.27** (0.29)	-0.56** (0.18)	-0.09 (0.35)
If everyone got the flu vaccine, it would prevent 50% of flu cases and flu deaths.	0.16* (0.08)	0.76** (0.10)	0.14 (0.13)	-0.59** (0.20)	0.25 (0.15)	-1.13** (0.17)	0.15 (0.15)	-0.86** (0.17)
Incentive								
You can receive free transportation to a vaccination site. (Ref)			Ref	Ref	Ref	Ref	Ref	Ref
You can receive a \$5 gift card for getting the flu vaccine.	0.96** (0.11)	1.91* (0.10)	1.82** (0.20)	1.89** (0.18)	1.17** (0.19)	2.18** (0.19)	-0.08 (0.19)	-1.74** (0.18)
You can receive a reminder text message/ phone call to get the flu vaccine this year.	0.47** (0.06)	0.39** (0.13)	0.29** (0.11)	0.61** (0.16)	0.88** (0.12)	0.13 (0.39)	0.40** (0.11)	0.45** (0.17)
You can receive the vaccine during the day and on evenings and weekends.	0.63** (0.07)	-0.51** (0.12)	0.52** (0.11)	0.26 (0.50)	0.96** (0.13)	-0.82** (0.18)	0.57** (0.13)	0.72** (0.18)
Access								
Somewhere you don't usually go and you need an appointment. (Ref)			Ref	Ref	Ref	Ref	Ref	Ref
Somewhere you go daily and you don't need an appointment.	2.18** (0.09)	1.42** (0.09)	2.07** (0.15)	1.23** (0.16)	2.93** (0.20)	1.84** (0.18)	2.07** (0.19)	1.59** (0.18)
Somewhere you go daily but you need an appointment.	0.10 (0.10)	0.72** (0.21)	0.19 (0.16)	0.15 (0.54)	0.28 (0.17)	-0.41 (0.44)	-0.13 (0.20)	1.14** (0.27)
Somewhere you don't usually go but you don't need an appointment.	1.31** (0.08)	0.66** (0.17)	1.27** (0.14)	-0.54 (0.28)	1.76** (0.18)	1.58** (0.23)	1.29** (0.15)	-0.56 (0.35)
Intercept								
Option 1	0.09* (0.04)	-0.58** (0.05)	0.19** (0.06)	-0.38** (0.11)	0.05 (0.07)	-0.74** (0.09)	-0.01 (0.07)	0.76** (0.09)
Observations	42,312		14,664		15,072		12,576	

*p-value<0.05; **p-value<0.01. Model: multinomial logistic regression models with random effects to account for individual-level heterogeneity. The coefficient estimate indicates the difference in partial utility between parameter_i and the reference parameter for each attribute. The standard deviation estimate indicates. Option 1 = Likelihood of preferentially selecting Option 1 "Get the flu vaccination in Situation A" across all choice sets. Observations signifies the total number of choices presented to each participant in each age group. Each participant received eight questions for inclusion in the analytic data set, and each of these choice sets contained three choices to decide between: "Get the flu vaccine in Situation A, Get the flu vaccine in Situation B, and I would not get the flu vaccine in either situation.

significant effect when compared to no intervention at all (Mussio & de Oliveira, 2022; Nowak et al., 2015).

One surprising finding was the relatively low effect of recall/reminders on vaccine willingness compared to the reference category of free transportation to the vaccination site. Recall/reminder interventions consistently been demonstrated to be effective in increasing influenza vaccination coverage compared to no intervention, particularly in older age groups (Jacobson Vann, Jacobson, Coyne-Beasley, Asafu-Adjei, & Szilagyi, 2018; Pich, 2019; Thomas & Lorenzetti, 2018). Although reminders have been shown to be an effective behavioral intervention in practice, when presented with hypothetical DCE situations, individuals could either undervalue the importance of reminders weigh other interventions factor more heavily into their influenza vaccine willingness.

4.1. Limitations

While this study has a number of strengths, including randomly assigned blocks of choice sets that enable causal inference of the relative contribution of each parameter to stated willingness to receive an influenza vaccine, it also has several limitations. First, because stated choices instead of real choices are collected, possible hypothetical bias

issues may arise leading participants to likely overstate their vaccine willingness. The vaccination literature suggests that vaccine willingness does not always lead to getting the vaccine (N. T. Brewer et al., 2007; Quinn et al., 2019; Santibanez & Kennedy, 2016). A review of the discrete choice literature found that stated choices were reasonably well-predicted using a DCE model with a sensitivity of 88% (95% CI 81, 92%), but the specificity was lower, at 34% (95% CI 23, 46%) (Quaife et al., 2018). Because we rely on random utility theory, we assume that participants know and express their true preferences (McFadden & Kenneth, 2000). However, the drivers of preferences in the moment of a decision may differ from the drivers that are considered in advance of a decision (Sheeran & Thomas, 2016). Additional research is needed to further assess the differential effect of age on the gap between vaccine willingness and vaccination behavior.

Inherent in the stated choice design is the measurement of vaccine willingness, rather than behavior, as is common in vaccination survey research. The population that may benefit the most from influenza vaccination interventions is the one that experiences this difference most acutely – coined the 'inclined abstainers' (Orbell & Sheeran & Thomas, 2016). Thus, we are relying on people to know what would motivate their actual behavior, rather than their vaccine willingness. While there may be discrepancies, we assume that these preferences

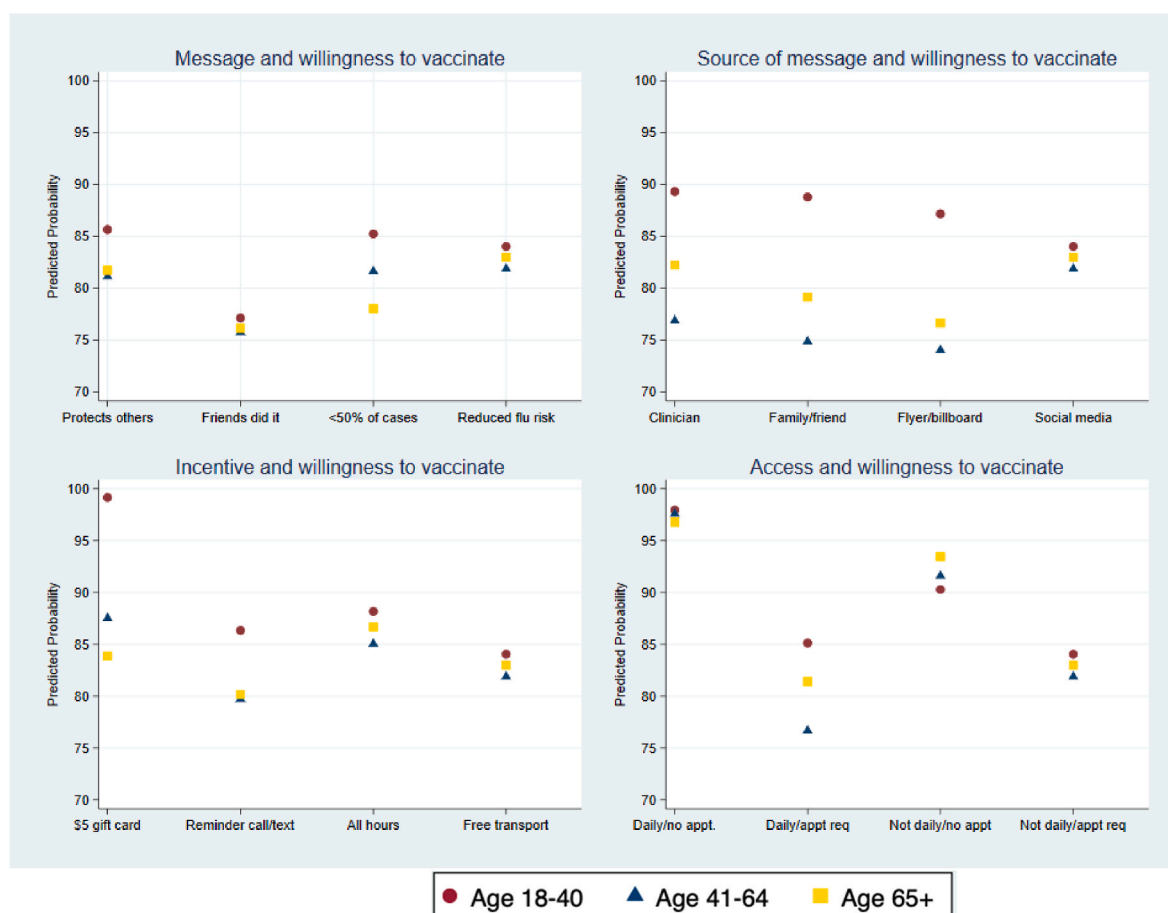


Fig. 2. Predicted probability of influenza vaccine willingness for each possible parameter, regardless of the other parameters presented in the two choice sets for three age groups of Minnesota residents^F

toward both vaccine willingness and behavior trend in a similar direction.

This study used a convenience sample of Minnesota adults volunteering at the University of Minnesota Driven to Discover Research Facility at the Minnesota State Fair. Over 88% of respondents reported a history of influenza vaccination, far above the 53% adult vaccination coverage reported in the previous influenza season (CDC, 2021a; 2021b). While the “flu facts” that framed the survey could have encouraged increased vaccine willingness, it is also possible that unmeasured factors that are associated with vaccine willingness may motivate individuals to choose to participate in a survey about vaccines. Other DCE studies using a different mode of data collection could be used to investigate specific populations, including vulnerable populations. Given this highly-vaccinated convenience sample, these findings would be most applicable in populations with similar experiences with influenza vaccines, attitudes towards vaccines, and preferences regarding vaccine delivery modalities.

5. Conclusion

We found high influenza vaccine willingness, which did not substantially differ by age group. Easy-access drop-in vaccination options increased vaccine willingness more than any of the other fifteen parameters examined. Small financial incentives were also associated with high vaccine willingness among young adults. Our results suggest that public health programs and vaccination campaigns may improve their chances of successfully increasing vaccine willingness by offering convenient access to vaccination and small monetary incentives, particularly for young adults.

CRedit statement

Kimberly E. Bonner: Conceptualization, Methodology, Investigation, Formal Analysis, Data Curation, Writing- Original Draft, Project Administration, Funding Acquisition. **Sandra Chyderiotis:** Methodology, Validation, Writing- Review and Editing. **Jonathan Sicsic:** Conceptualization, Methodology, Validation, Writing- Review and Editing. **Judith E. Mueller:** Conceptualization, Methodology, Validation, Writing- Review and Editing. **Angela K. Ulrich:** Methodology, Writing- Review and Editing. **Traci Toomey:** Conceptualization, Methodology, Writing- Review and Editing, Supervision. **Keith J. Horvath:** Writing- Review and Editing, Supervision. **James D. Neaton:** Methodology, Writing- Review and Editing, Supervision. **Nicole E. Basta:** Conceptualization, Methodology, Writing- Review and Editing, Supervision, Project Administration, Funding Acquisition.

Declaration of competing interest

The authors declare that the funders had no role in the role in the design of the study or in the analysis and interpretation of data.

Data availability

Data will be made available on request.

Acknowledgements

The authors would like to acknowledge the Driven to Discover Research Facility (D2D) for providing a venue in which to conduct this

study at the Minnesota State Fair.

This work was supported by the US National Institutes of Health, National Institute of Allergy and Infectious Diseases [Award Number R01AI132496 PI: Dr. Nicole E. Basta], the Canadian Institutes of Health Research to support Dr. Nicole E. Basta's research, and the J.B. Hawley Student Research Award, University of Minnesota School of Public Health [Awarded 2018].

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2023.101384>.

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