Perceived COVID-19 vaccine attributes associated with early adoption among adults in rural Indiana

Kristina Hunter-Mullis1,*, Jonathan T. Macy1, Alison Greene1 and Kosali Simon2

1Department of Applied Health Science, School of Public Health-Bloomington, Indiana University, 1025 E. 7th St., Room 116, Bloomington, IN 47405, USA and 2O’Neill School of Public and Environmental Affairs, Indiana University, 1315 E. 10th St., Bloomington, IN 47405, USA

*Correspondence to: K. Hunter-Mullis. E-mail: hunterki@iu.edu

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Abstract

2019 Novel coronavirus (COVID-19) vaccination rates in the United States have plateaued in specific populations, including rural areas. To improve COVID-19 vaccination rates and to encourage early vaccine uptake in future pandemics, this study aimed to examine vaccine attributes associated with early adoption. Data are from an anonymous online survey of adults using targeted Facebook pages of rural southern Indiana towns in January and February 2021 (n = 286). The diffusion of innovation theory states that the rate of adoption of a product in a specific population is explained by five perceived attributes: relative advantage, compatibility, observability, complexity and trialability. Binary logistic regression analyses were used to examine the association of Diffusion of Innovation theory attributes of the COVID-19 vaccine on early adoption. Results indicated that trialability [odds ratio (OR) = 3.307; 95% confidence interval (CI) = 1.964–5.571; P < 0.001], relative advantage (OR = 2.890; 95% CI = 1.789–4.667; P < 0.001) and compatibility (OR = 2.606; 95% CI = 1.476–4.601; P < 0.001) showed significant independent associations with early adoption. Furthermore, age and political ideology were significant moderators of complexity and relative advantage, respectfully. Health education strategies for early vaccine uptake should focus on building trust in vaccine safety, increasing short-term benefits of vaccination and promoting relatability to personal values.

Introduction

Vaccination has greatly reduced the burden of infectious diseases and remains one of the most successful and cost-effective public health interventions [1, 2]. However, infectious diseases remain a major cause of global illness, disability and death, and adult vaccination rates remain low and below national targets [3, 2]. Improving adult immunization rates is critical to protecting the population from harm associated with infectious diseases. On 31 January 2020, the World Health Organization declared the 2019 novel coronavirus (COVID-19) outbreak to be a public health emergency [4]. As of July 2022, more than 567 million cases and more than 6.3 million deaths have been reported [5]. On 11 December 2020, the US Food and Drug Administration issued the first emergency use authorization for a vaccine for the prevention COVID-19 in individuals 16 years of age and older, with multiple vaccines now approved for use in individuals 6 months of age and older [6].

While COVID-19 vaccination rates continue to increase in the United States, interest has plateaued [7]. According to the Centers for Disease Control and Prevention COVID-19 Vaccine Tracker, 79% of the total eligible US population have received at least one dose of the vaccine, with 68.2%...
fully vaccinated, as of 16 September 2022 [8]. To increase these percentages, states and organizations will need to address barriers associated with vaccination uptake. Particularly important is the focus on decreasing vaccine hesitancy—a delay in acceptance or refusal of vaccines despite the availability of vaccination services. Historically, vaccine hesitancy has been reported in more than 90 countries in the world, and it remains a major worldwide public health concern [2].

Studies indicate that the currently available vaccines are safe and effective, reducing the risk for COVID-19-associated hospitalization, post-COVID-19 conditions and deaths [9, 10, 11]. However, hesitancy to receive the COVID-19 vaccine persists. Recent data indicate that individuals living in rural areas, those with lower household incomes and those with lower levels of education were more likely to be hesitant about getting immunized with a COVID-19 vaccine [12]. Rural and urban disparities in vaccine uptake have been previously documented, with rural populations consistently experiencing a larger gap in vaccination rates for HPV, pneumococcal, influenza and measles [13, 14, 15, 16, 17]. Individuals living in rural areas in the United States were also significantly less likely to say they will get a COVID-19 vaccine that is deemed safe and available for free (31%) than individuals living in suburban (43%) and urban (42%) America [18].

Factors accounting for vaccine hesitancy in rural areas are not fully understood. For example, for rural residents, obtaining a COVID-19 vaccine was perceived more as a personal choice (62%) than as part ‘of everyone’s responsibility to protect the health of others’ (36%) [22]. Individual characteristics related to hesitancy can include preexisting vaccine hesitancy, lower awareness and health literacy, lower trust and interaction with healthcare professionals, vaccine safety concerns and cost-based concerns [19]. Generally, men, younger individuals and those with less education have been less likely to be vaccinated for COVID-19 [20, 12, 21]. However, research is needed to determine the significant perceptions of the vaccine itself that are related to hesitancy among these populations. This is particularly important during the first months of the vaccine rollout prior to wide-scale vaccination, when individuals had little personal experience with the vaccine and less data existed about the vaccine.

The diffusion of innovation theory is applicable when examining the challenging public health concern of vaccine adoption [22]. This theory defines diffusion as the process by which an innovation is communicated through certain channels over time among the members of a social system [22]. Within the DOI, individuals are classified into one of five mutually exclusive categories of adopters, including innovators, early adopters, early majority, late majority and laggards. In this theory, innovators are those who typically want to be the first to adopt the innovation and play a gatekeeping role in the flow of new ideas into a system. Early adopters are typically aware of the need to change and are very comfortable adopting new ideas. The early majority include those who adopt new ideas before the average person. Late majority includes those who are skeptical of change and will usually only adopt an innovation after it has been tried by the majority. Finally, laggards tend to be more traditional, are skeptical about change and are the most difficult group to adopt an innovation [22]. In addition, the majority of variance in the rate of adoption is explained by five perceived attributes: relative advantage, compatibility, observability, complexity and trialability. Relative advantage is defined as the degree to which an innovation is perceived as better than the idea, program or policy it replaces. Compatibility is the degree to which an innovation is perceived as consistent with the values, experiences and needs of the potential adopters. Complexity is how an innovation is perceived as difficult to understand and/or use. Trialability is the extent to which the innovation can be tested or experimented with before a commitment to adopt is made. Observability is the extent to which the results of an innovation are visible to others [22]. Rogers [22] suggests that innovations with high relative advantage, compatibility, trialability,
Perceived COVID-19 vaccine attributes in rural Indiana

Observability and low complexity are most likely to succeed.

Prior studies have applied the DOI to several health-related innovations, including the adoption of technology in health care, chronic disease management programs, new drugs or medical ideas adopted by doctors and patients, family planning methods, human immunodeficiency virus/acquired immunodeficiency syndrome prevention and more [23, 24, 25, 22, 26]. Studies of vaccination behavior have largely applied the DOI to examining new vaccine uptake, particularly among influenza and human papillomavirus vaccinations; addressing the role of opinion leaders and networks; and channels of information diffusion [27, 28, 29, 30]. Mo et al. [31] applied an adapted version of the DOI and found that perceived efficacy of the COVID-19 vaccine, social media use for COVID-19 vaccine information, individual openness to experience and descriptive norm were all positively associated with the intention to receive the COVID-19 vaccine. However, additional studies are needed to understand the perceived attributes of the COVID-19 vaccine associated with early adoption to improve rates among hesitant populations.

The objective of this study is to examine how perceived attributes of the COVID-19 vaccine were associated with early adoption among adults living in rural southern Indiana during the early months of vaccine rollout. Following the DOI theory’s general suggestions, we hypothesize that perceptions of high relative advantage, compatibility, trialability, observability and low complexity will be significant predictors of early adoption of the COVID-19 vaccine.

Methods

Sample
This study used a cross-sectional design with a convenience sample of adults from southern Indiana. Adults (n = 323) were recruited through 11 community-based Facebook groups targeting rural towns in Lawrence, Orange, Crawford, Washington and Martin counties from January 12 to 22 February 2021. The largest towns in each county were identified, and a search of Facebook pages relating to those communities was conducted. Community pages such as Bedford Indiana Chatter, Paoli Talk, Crawford County Talk and county COVID Connectors were targets for recruitment, as well as community organization pages such as Southern Indiana Community Health Care and Purdue Extension—Orange County. Participants were asked to complete an anonymous online survey with 22 multiple-choice or scaled items and demographic items that could be completed in ~10 min or less. For analyses, only participants who consented to the study, were 18 years of age or older, indicated living in one of the rural Indiana counties listed above and who completed all survey items were included in the final sample (n = 286). This study was deemed to be exempt from full Institutional Review Board approval by the author’s institution because the research was no more than minimal risk to participants.

Measures
The outcome variable for this study categorized participants as members of innovation adoption categories based on the DOI theory. Participants were asked, ‘Vaccines to prevent coronavirus/COVID-19 have been approved by the FDA for use in the United States. The vaccines will be available to different people at different times. Did you already get a vaccine?’ Responses were either ‘YES’ or ‘NO’. If participants responded ‘NO’, they were then asked, ‘When will you make an appointment to be vaccinated?’ Responses included ‘within one week’, ‘within one month’, ‘within 6 months’, ‘within one year’, ‘more than one year’ and ‘I don’t plan to get it’. Because of sample size limitations, participants were classified into only two categories: early adopters or vaccine hesitant. To be classified as early adopters, participants responded that they had already received at least one COVID-19 vaccine dose or that they would make an appointment to be vaccinated within 1 week of being eligible. As the survey was conducted in January and February 2021, the first months of vaccine distribution, early adopters
in this group would essentially include the most highly vaccine motivated and now earliest vaccinated adults. Participants who responded that they had not yet received a dose of the vaccine and that they would make an appointment to be vaccinated within 3 months, within 6 months, within 1 year or >1 year after being eligible or those who said they did not plan to get it were considered late majority/laggards and were labeled as vaccine hesitant. For analyses, the outcome variable was coded as a binary variable of early adopters (1) and vaccine hesitant (0).

The main independent variables included the DOI theory innovation attributes of relative advantage, compatibility, observability, complexity and trialability. Each attribute was treated as a continuous variable and measured with a statement consisting of a Likert scale of 1–5 (strongly disagree to strongly agree). The selected items were adapted from a study of pooled scaled items and instruments developed to measure perceptions of adopting an information technology innovation by Moore and Benbasat [32]. The items were as follows: (i) relative advantage: ‘Receiving the COVID-19 vaccine will allow me to get back to “normal” life more quickly’, (ii) compatibility: ‘I can easily fit getting the COVID-19 vaccine into my life and schedule’, (iii) observability: ‘I have seen or heard of other people getting the COVID-19 vaccine’, (iv) complexity (written as low complexity): ‘The process of making an appointment to get the COVID-19 vaccine is clear and understandable’ and (v) trialability: ‘There have been enough COVID-19 vaccine studies completed prior to the wide-scale launch of the vaccine’.

Gender, age, education and political ideology were included as control variables and tested as moderators of DOI attributes. Gender was coded as a dichotomous variable of female (1) and male (0). Age was treated as a continuous variable. To combine education-level categories with few responses, education was coded as bachelor’s degree or higher (1) or less than a bachelor’s degree (some college, high school diploma/General Educational Development or did not complete high school) (0).

Finally, political ideology was included as a continuous variable ranging from 1 to 7, indicating very conservative to very liberal. Race was not included as a covariate as demographics of counties included in the study indicate that populations are greater than 95% White (U.S. Census Bureau, 2022)[33].

Data analysis
To explore differences among the early adopters and vaccine-hesitant adults, frequencies and descriptive statistics were conducted after splitting the sample into the two separate categories. Frequencies and percentages were computed for categorical variables, with means and standard deviations calculated for continuous variables. Chi-square tests were conducted between groups for each covariate. Means and standard deviations were calculated for each DOI characteristic, with t-tests comparing the means between the early adopters and vaccine-hesitant groups. We then conducted binary logistic regression models to examine the association of the DOI innovation attributes on being an early adopter of the COVID-19 vaccine above and beyond the contribution of the covariates. Finally, to test for moderating effects of the four demographic characteristics’ relationships among the five DOI attributes and the likelihood of early vaccine adoption, we entered the two-way interactions between all demographics and the five DOI attributes individually. A median split was used to create two age groups 18–45 [n = 146 (51.0%)] and 46 and above [n = 140 (49.0%)]. Education was dichotomized to two groups: less than bachelor’s degree [n = 125 (43.7%)] and bachelor’s degree or higher [n = 161 (56.3%)]. Gender was dichotomized to two groups: male [n = 57 (19.9%)] and female [n = 229 (80.1%)]. Political ideology was tested at three points: the mean and 1 SD above and below the mean (mean = 4.14; SD = 1.76). All values for demographics and DOI attributes were mean-centered before computing the interaction terms, and insignificant interactions were not included in the final model. The level of significance was set to $P<0.05$, with odds ratios (ORs) and 95% confidence intervals.
Results

Descriptive statistics are provided in Table I. Nearly 70% of this sample was classified as early adopters (n = 200), including 30% of adults who had already received at least one COVID-19 vaccine. The sample was also majority female (80.0%), limiting comparisons among groups based on gender. Vaccine-hesitant adults (n = 86) made up 30% of this sample, mirroring estimates within the US population at the time of the study [18]. Early adopters had a mean age of 49.6 (SD = 14.41). More than 60% of early adopters had a bachelor’s degree or higher, and 50% classified themselves as liberal as opposed to moderate (18.5%) or conservative (31.5%). Participants who were vaccine hesitant varied significantly from the early adopters in nearly all demographics. The vaccine-hesitant adults were significantly younger with a mean of 42.1 (SD = 2.97), were significantly less educated with 58.1% having less than a bachelor’s degree and were more conservative at 46.6% as opposed to 27.9% moderate and 25.5% liberal. Early adopters and vaccine-hesitant adults also varied significantly on the vaccine DOI attributes. As expected, early adopters had significantly higher mean scores for all attributes, including relative advantage, compatibility, observability, complexity and trialability, indicating generally higher enthusiasm for the vaccine.

Results of the binary logistic regression models are presented in Table II. Model 1 examines the contribution of the covariates on being an early adopter of the COVID-19 vaccine. While all demographics except for gender were statistically significant, this did not hold for the DOI model, as shown in Model 2, or the final model shown in Model 3. In the full model, trialability (OR = 3.307; 95% CI = 1.964–5.571; P < 0.001), relative advantage (OR = 2.890; 95% CI = 1.789–4.667; P < 0.001) and compatibility (OR = 2.606; 95% CI = 1.476–4.601; P < 0.001) showed significant independent associations with early adoption of the COVID-19 vaccine. Age, gender, education, political ideology, observability and complexity did not show significant independent associations with early adoption. The testing of interactions resulted in age significantly moderating complexity (OR = 0.690; 95% CI = 0.533–0.893; P = 0.002) and political ideology significantly moderating relative advantage (OR = 0.931; 95% CI = 0.895–0.968; P < 0.001). Further probing of these interactions indicated that low complexity was significant for those 45 years of age or younger only (OR = 2.541; 95% CI = 1.235–5.124; P = 0.036). Relative advantage was significant for more conservative (OR = 12.450; 95% CI = 1.311–19.134; P = 0.034) and moderate (OR = 6.543; 95% CI = 1.278–33.954, P = 0.041) political ideologies only. The final model was significant with a Nagelkerke R² of 0.748 (P < 0.001), an increase from 0.196 in Model 1.

Discussion

Efforts to increase the percentage of vaccinated Americans must target populations that remain hesitant—including those living in rural areas. While prior studies have examined individual person-level characteristics that predict hesitancy, research has not considered whether the reasons people are hesitant are systematically related to the perceived characteristics of the vaccine itself. The objective of this study was to examine diffusion of innovation attributes of the COVID-19 vaccine on early adoption among adults living in rural southern Indiana during the first months of vaccine rollout.

Early adopters and vaccine-hesitant adults differed significantly on demographic factors. Significant differences were found in age, education and political ideology. Early adopters were, on average, older than the vaccine-hesitant group. In addition, early adopters were significantly more educated with bachelor’s degrees or higher. Previous research has shown that those who are less educated...
K. Hunter-Mullis et al.

Table I. Descriptive statistics of COVID-19 vaccine early adopter and hesitant adults (n = 286)

|                       | Early adopters (n = 200) | Vaccine hesitant (n = 86) | \( \chi^2 \) |
|-----------------------|--------------------------|---------------------------|--------------|
| Gender                |                          |                           | 0.361        |
| Female                | 162 (81.0)               | 67 (77.9)                 |              |
| Male                  | 38 (19.0)                | 19 (22.1)                 |              |
| Age                   |                          |                           | 11.42***     |
| Mean (Standard deviation) | 49.6 (14.41)              | 42.1 (12.97)              |              |
| 18–45                 | 89 (44.5)                | 57 (66.3)                 |              |
| 46+                   | 111 (55.5)               | 29 (33.7)                 |              |
| Education             |                          |                           | 10.413**     |
| Less than bachelor’s degree | 75 (37.5)             | 50 (58.1)                 |              |
| Bachelor’s degree or higher | 125 (62.5)          | 36 (41.9)                 |              |
| Political ideology    |                          |                           | 15.844*      |
| Very conservative     | 12 (6.0)                 | 9 (10.5)                  |              |
| Conservative          | 27 (13.5)                | 17 (19.8)                 |              |
| Slightly conservative | 24 (12.0)                | 14 (16.3)                 |              |
| Moderate              | 37 (18.5)                | 24 (27.9)                 |              |
| Slightly liberal      | 31 (15.5)                | 5 (5.8)                   |              |
| Liberal               | 50 (25.0)                | 14 (16.3)                 |              |
| Very liberal          | 19 (9.5)                 | 3 (3.5)                   |              |
| Vaccination status    |                          |                           | 32.650***    |
| Vaccinated (1+ dose)  | 60 (30.0)                | 0 (0)                     |              |
| Not vaccinated        | 140 (70.0)               | 86 (100)                  |              |
| DOI characteristics   | Mean (SD)                | Mean (SD)                 | t-value      |
| Relative advantage    | 4.18 (0.82)              | 2.45 (1.23)               | 13.941***    |
| Compatibility         | 4.59 (0.69)              | 3.27 (1.14)               | 12.015***    |
| Observability         | 3.59 (0.96)              | 2.79 (0.94)               | 6.453***     |
| Complexity            | 3.61 (1.13)              | 2.94 (0.93)               | 4.796***     |
| Trialability          | 3.68 (0.90)              | 2.05 (0.99)               | 13.633***    |

*P < 0.05; **P < 0.01; ***P < 0.001.

are less likely to receive the COVID-19 vaccine [35]. Health education interventions should incorporate strategies to ensure health literacy among all populations. Finally, early adopters were significantly more liberal than the vaccine-hesitant group. The COVID-19 pandemic has been heavily politicized, with literature suggesting that those who are more conservative are less likely to intend to receive a COVID-19 vaccine [18, 36, 35]. Therefore, considerations of perceptions and values among political parties, such as gained through focus groups, should be used during intervention planning.

Perceptions of high trialability, relative advantage and compatibility were the only DOI attributes to show a significant independent association with early adoption. Trialability was the strongest attribute predicting early adoption. Relatively earlier adopters of an innovation perceive trialability as more important than do later adopters [22]. In this sample, early adopters had a positive perception about trusting COVID-19 vaccine trials, but this was opposite for the vaccine-hesitant adults. Safety and vaccine development concerns have been a prominent barrier for COVID-19 vaccine uptake among many populations [37, 38, 39]. To build trust in newly distributed vaccines, education with more transparency of vaccine development and testing should be considered. In addition, early-phase pandemic adult vaccine clinical trials
have historically lacked diversity, with White participants commonly overrepresented [40]. This issue persisted in COVID-19 vaccine trials, with 73.6% of participants in Pfizer and Moderna vaccine clinical trials being White [41]. As vaccines can impact groups differently and reflect variation in environmental and experiential exposures, increasing diversity early in the trial stage is critical to build trust. Building trust is not a one-size-fits-all approach, and community-specific strategies are needed. In rural Wyoming, for example, state health leaders met with trusted local community messengers to build confidence and implemented strategies such as peer-to-peer panel discussions [42].

Relative advantage was the second strongest attribute predicting early adoption. Subcomponents of relative advantage can include economic profitability, low initial cost, a saving of time and effort, and immediacy of reward [22]. In the United States, individuals could receive the COVID-19 vaccine at no cost through the Coronavirus Aid Relief, and Economic Security Act and other vaccination programs [43]. However, a critical component to address for vaccine uptake is the immediacy of reward. Preventive innovations that an individual adopts now to lower the probability of some unwanted future event, such as vaccines, generally have an especially slow rate of adoption [22]. Information about benefits of vaccines and recommendations provided by reliable sources, such as health care providers, have previously shown importance in the uptake of vaccines among a variety of populations and should be a focus of health education campaigns [44, 45, 46]. Other interventions that influence relative advantage include both positive and negative incentives and the implementation of mandates. Employers, health insurance providers, businesses and corporations have implemented monetary and non-monetary incentives for receiving the COVID-19 vaccine [47]. Increasing short-term rewards for vaccination may increase the likelihood of adoption.

The final significant attribute related to early adoption was compatibility. Compatibility of an innovation with a preceding idea can either speed up or slow its rate of adoption, as old ideas are the main mental tools individuals use to assess new ideas and give them meaning [22]. Historically,
vaccination has been a highly charged and debated topic, and the COVID-19 vaccine is no different [48]. To improve perceptions of compatibility, branding and positioning to previous ideas is an important tool [22]. As compatibility had the highest mean perceptions of all attributes among both early adopter and vaccine-hesitant groups, interventions and messaging should continue to promote the compatibility of vaccination with personal lifestyles and values. Messaging that aligns the COVID-19 vaccine to previously successful vaccine campaigns throughout history such as polio or HPV or to other preventive health measures may improve beliefs on compatibility.

Significant interactions of age and political ideology were found for two DOI attributes: complexity and relative advantage. Low complexity or the perception that making an appointment is easy and understandable was a significant factor for adults 18–45 years old to opt for vaccination. This differed from adults 46 years old and older, where low complexity was not significant. This is likely for multiple reasons. First, severity and outcome of COVID-19 infection were largely dependent on a patient’s age [35]. Adults >65 years of age represented 80% of hospitalizations and had a 23-fold greater risk of death than those <65 years old [49]. Older adults may be more likely to opt for the vaccine regardless of ease of scheduling. Younger adults are more likely to consider themselves as healthy and not in need of vaccines and often have competing priorities, such as work, family or school responsibilities [50, 51]. In addition, political ideology should be considered with messages relating to relative advantage. Relative advantage was found to be a more important factor for those who consider themselves conservative or moderate as opposed to liberal. With the influence of media and politicization of COVID-19, this is an important distinction for health education strategies [52, 18].

Limitations and future research

This study used a theory-based approach to examine COVID-19 vaccine attributes associated with early adoption. However, this study also had limitations. The current study incorporated a convenience sample of adults who were members of specific Facebook groups targeting rural Indiana towns. As these data were collected during COVID-19 restrictions that prohibited any in-person interactions, a social media recruitment was necessary in the timeframe. However, using social media platforms may limit generalizability. In addition, participants from Facebook recruitment may be predisposed to differences in the general rural population that could impact the application of the diffusion of innovation theory. Additional studies using nationally representative samples would improve generalizability. Although the early deployment of the survey is a strength of the study, it is also a limitation that the study is cross-sectional and does not reflect the continuous changes related to COVID-19 vaccination. Additional longitudinal studies of vaccine confidence or vaccine hesitancy are needed to track perceptions and attitudes over time.

Conclusions and applications

Health education strategies for early vaccine uptake should focus on building trust in vaccine safety, increasing short-term benefits of vaccination and promoting relatability to personal values. Building trust in the safety of the vaccine could include communicating clearly and consistently about the development, safety and efficacy of the vaccine, as well as community-based approaches to reaching all populations. Increasing short-term benefits, such as providing incentives, as well as aligning perceptions of vaccination to individual values would likely increase uptake. Finally, efforts to target compatibility may include aligning the vaccine to other successful public health campaigns, such as polio eradication efforts or the wearing of seat belts. As increasing vaccination rates is not a one-size-fits-all approach, communities would benefit from gathering insights from their residents and continuously monitor, evaluate and change strategies as necessary.
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Conflict of interest statement

None declared.

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