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Understanding influenza vaccination attitudes and behaviors: An assessment of health decision-making preferences

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ABSTRACT

Less than half of American adults comply with annual influenza vaccination recommendations. Stagnating flu vaccination rates suggest new approaches, particularly ones using theory-based approaches, are needed to better understand influenza vaccination beliefs, behaviors, and intentions. Health decision-making preferences are an important consideration rarely accounted for in understanding vaccination behavior and thus may provide further insight into stagnating vaccination rates. Building on the work of Groopman and Hartzband (2012), this study considers health decision-making preferences as a determinant of vaccination attitudes and behavior and introduces an instrument for measuring them. We constructed a measure of health decision-making preferences using population representative surveys of U.S. adults 18 years old and older, drawn from the National Opinion Research Center's (NORC) AmeriSpeak® Panel. We used ordinary least squares (OLS) regression to determine the relative explanatory power of health decision-making preferences in predicting vaccine confidence, vaccine hesitancy, recent vaccination behavior and future vaccination intention. In an initial assessment, our health decision-making preferences measure was significantly correlated with measures of vaccine confidence and vaccine hesitancy, prior flu vaccination and flu vaccination intentions.

1. Introduction

In 2010, the United States Centers for Disease Control and Prevention (CDC) Advisory Committee on Immunization Practices (ACIP) broadened the recommendation for annual influenza ("flu") vaccination to all persons 6 months and older who did not have known contraindications [1]; a recommendation that remains in place today [2]. However, the percentage of adults in the U.S. who receive a seasonal influenza vaccination has not significantly changed since 2010 and remains far below the 70 % target of the Department of Health and Human Services' Healthy People 2030 program [3,4]. Annual surveys conducted by academic scholars and health organizations like the CDC, typically find that roughly half of U.S. adults comply with the flu vaccine recommendation during any given year [4–6]. A within-season flu vaccination survey conducted in Spring 2025 estimated that 46.7 % of U.S. adults had received a flu vaccination [7]. Closing the gap between current and target flu vaccination rates is critical to achieving public health goals such as reducing influenza-related morbidity and mortality and minimizing the burden on healthcare systems during peak flu seasons [3,8].

The gaps between target goals and actual immunization rates have motivated a growing body of research designed to better understand the barriers and facilitators of adult flu vaccination in the U.S. To date, much of this work has focused on demographic characteristics, knowledge, and beliefs or perceptions about the vaccine or influenza [5,9–13]. In addition, much research has found that physician recommendations are often a primary determinant of vaccination intention and behavior [14–17]. Conversely, lack of knowledge in the general adult population about influenza transmission and disease severity are considered significant barriers to flu vaccination receipt [18–20]. Despite the insights

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gained from these studies, flu vaccination rates have plateaued in the U. S. [9–13], and there has been a lack of success in increasing flu vaccination uptake among adults. Schmid et al.'s (2017) systematic review of studies focused on the barriers of influenza vaccination intention and behavior from 2005 to 2016 illustrated that new directions are needed to improve the knowledge base for designing evidence-informed interventions and communication strategies. One concept that may hold promise involves the decision-making preferences that adults draw upon when making health and medical decisions. Health decision-making preferences are the factors or considerations individuals generally favor or weigh more heavily when making health-related decisions [17,21], including whether to adopt recommended preventative measures, such as getting a recommended vaccine. In this work we include, but move beyond, factors already shown to be associated with flu vaccination, such as demographics, physician recommendations, and vaccine confidence and hesitancy, to examine the relationship between health decision-making preferences and flu vaccination attitudes and behaviors.

Drawing from patient experiences as well as research in psychology and cognitive science, Groopman and Hartzband [21] identified three general categories of decision-making preferences that they proposed greatly influenced patients' health treatment decisions. The three categories are: (1) whether individuals had a "natural or naturalism" orientation (i.e., a preference for helping the body heal itself, including with herbs, vitamins and other natural products) versus "technology" orientation (i.e., a preference for evidence and science-based approaches, including new pharmaceutical medications and procedures); (2) whether individuals had a "minimalist" orientation (i.e., a preference for "less is more" approaches that avoided or reduced the use of medicines and treatments) or "maximalist" orientation (i.e., a preference for being proactive about health and believing that more interventions are better for achieving desired health outcomes); and (3) whether individuals were "doubters" (i.e., generally approached treatment options with skepticism, risk-aversion, and a primary focus on the side effects and limitations of drugs and procedures) or "believers" (i.e., generally approached treatment options trusting science and healthcare providers, were benefit-focused, and generally believed outcomes would be positive). The "Medical Mind" idea was based on Groopman and Hartzband's experiences with patients, and conceptualized with the goal of improving their understanding of patients' thought processes so they could better assist them in making responsible medical decisions [21]. The concept was originally framed around non-communicable diseases, and remains unexamined as it relates to infectious diseases, including attitudes and behaviors concerning vaccination. Groopman and Hartzband's framework may have significant value for examining and advancing our understanding of adults' influenza vaccination intentions and behaviors, including, by examining how vaccination beliefs and attitudes relate to health decision-making preferences. Specifically, the framework would predict that adults whose health decision-making preferences have technology, maximalist, and believer orientations should have more favorable beliefs and higher confidence regarding influenza vaccination and be more likely to receive annual vaccinations compared with adults whose health decision-making preferences are oriented toward naturalism, minimalism, and doubt.

In this work we combine the three health decision-making preference dimensions into an overall measure of health decision-making preference to assess its value in understanding vaccination decision-making. If health decision-making preferences are associated with influenza vaccination beliefs, confidence, behavior, and intentions, immunization programs and providers can utilize that knowledge when communicating with their patients. Research has found that the way information is presented or tailored often influences people's decisions [22–24], including in the context of vaccinations [25,26]. Knowing whether health decision-making preferences are associated with flu vaccination-related outcomes can increase the ability of immunization programs and healthcare providers to present information in more tailored ways that better resonate with communities and patients.

This study examined the "Medical Mind" concept for how adults make medical treatment decisions by 1) developing an operational measure of health decision-making preferences and 2) assessing its utility for understanding and improving influenza vaccination acceptance. For this study we defined *vaccine confidence* as trust in the safety, effectiveness, and benefits of vaccines; *vaccine hesitancy* as the respondents' reluctance to receive the recommended vaccination; and *vaccination intention* as the willingness or plan to receive a flu vaccination. The specific hypotheses assessed in our study were:

H1. Individuals scoring higher on our overall measure of health decision-making preferences will have (a) higher reported levels of vaccine confidence, and (b) lower reported levels of vaccine hesitancy compared to lower scoring individuals.

H2. Individuals scoring higher on our overall measure of health decision-making preferences will report (a) more frequent recent flu vaccination receipt, and (b) higher future flu vaccination intentions compared to lower scoring individuals.

2. Methods

To examine the hypotheses outlined, we used data from two general population surveys of U.S. adults 18 years old and older, drawn from the National Opinion Research Center's (NORC) AmeriSpeak® Panel [27]. Both samples were stratified by age, race/ethnicity, education, and gender. Sampling weights were collected during 2016 and thus used in the analysis of those data; sampling weights were not collected in 2018.

Surveys were fielded in October 2016 and October 2018 in English and Spanish, using internet and telephone, though most respondents in both surveys responded via computer. There were 1005 respondents to the 2016 survey and 1020 respondents to the 2018 survey. The American Association of Public Opinion Research weighted cumulative response rates (RR3 [28]), as reported by NORC, were 8.9 % for the 2016 survey, and 7.8 % for the 2018 survey. The study was reviewed and approved by the University of Georgia Institutional Review Board. Panelists received the cash equivalent of $3 for completing the survey.

2.1. Independent variables.

Gender, age, race, household income, and education were included in our model to control for demographic influences on the dependent variables. *Gender* was a dichotomous variable with male coded as '1' and female coded as '2' (2016 (weighted): 51.8 % female; 2018 (unweighted): 51.1 % female). *Age* was measured as a continuous variable (2016 (weighted) *Mean* = 47.9, *SD* = 18.1; 2018 (unweighted): *Mean* = 48.6, SD = 16.8). *Race* was measured as a dichotomous variable where White respondents were coded as '1' and all other respondents were coded as '0' (2016 (weighted): 64.6 % White; 2018 (unweighted) 65.6 % White). *Household income* was measured with an 18-category measure that ranged from "less than $5,000" to "$200,000 or more" (2016, *Mdn* = "$40,000 to $49,999", 2018, *Mdn* = "$50,000 to $59,999"). *Education* was assessed with a fourteen-category measure that ranged from "No formal education" to "Professional or doctorate degree" (2016, *Mdn* = "Some college, no degree", 2018, *Mdn* = "Some college, no degree").

Perceived Flu Knowledge was measured with four items that asked respondents to report on four-point scales ranging from "Not at all informed" (coded as '1') to "Very well informed" (coded as '4') how well informed they were about a) seasonal flu, b) who should receive a seasonal flu vaccine, c) the benefits of receiving a seasonal flu vaccine, and d) the risks of not receiving a seasonal flu vaccine. Responses to these four questions were averaged to create an index of how well-informed participants believed themselves to be about flu disease and flu vaccination (2016 (weighted): *Mean* = 3.3, *SD* = 0.7, α = *0.92;* 2018 (unweighted): *Mean = 3.3, SD = 0.6,* α = 0.889). *Healthcare Recommendation* was measured with a single survey item that asked respondents to report whether, in the past year, a physician or healthcare provider told them that they should receive an influenza vaccine (2016 (weighted): "Yes" = 56.1 %; 2018 (unweighted): "Yes" = 67.1 %).

Flu Seriousness was assessed with a single survey question that asked respondents to report how serious they thought the flu illness would be for them personally, using four-point scales (1 = "Not at all serious," 4 = "Very serious") (2016 (weighted): *Mean* = 2.5, *SD* = 0.8; 2018 (unweighted): *Mean = 2.5, SD = 0.7*). *Flu Spread* was measured using a four-point scale (1 = "Very unlikely," 4 = "Very likely") by asking respondents to report the likelihood that if they were infected they could transmit the flu to someone else (2016 (weighted): *Mean* = 3.0, *SD* = 0.9; 2018 (unweighted): *Mean = 3.0, SD = 0.8*). Vaccine *Access Difficulty* was assessed using a single-item measure that asked respondents to indicate how easy or difficult (1 = "Very easy," 4 = "Very difficult") it would be for them to get a flu shot or vaccination if they wanted one (2016 (weighted): *Mean* = 1.3, *SD* = 0.6; 2018 (unweighted): *Mean = 1.3, SD = 0.6*).

Overall Health Decision-Making Preference was assessed by having respondents evaluate six pairs of statements, each anchored with different preference options based on the health decision-making preference dimension descriptions of Groopman and Hartzband (2012) (Table 1). Two sets of statements were associated with each of the three underlying preference dimensions, that is, (a) whether they preferred natural or technology-based health interventions, (b) whether they were a doubter or believer in mainstream medicine, and (c) whether they preferred minimal or maximum intervention in their health. To operationalize this concept we constructed a Likert scale scoring system to capture a range of agreement with the first item or the second item in each of the three sentence pairs (1 = "Totally agree with the first item," 2 = "Mostly agree with the first item," 3 = "I do not side with either item," 4 = "Mostly agree with the second item," and 5 = "Totally agree with the second item"). The three pairings were: (a1) "I prefer natural ways to prevent and treat illness" vs. "I prefer mainstream medicine approaches to prevent and treat illness" and (a2) "I prefer complementary or alternative medicine approaches to staying healthy and treating disease" vs. "I prefer science and evidence-based medicine approaches to staying healthy and treating illnesses," (b1) "I am most interested in the risks and potential side effects of a recommended drug or medicine." vs. "I am most interested in the benefits and value of a recommended drug or medicine," (b2) "I usually doubt health and medical advice from doctors and experts" vs. "I usually trust health and medical advice from doctors and experts," (c1) "When sick or ill, I prefer as little medicine or treatment as possible" vs. "When sick or ill, I prefer as much medicine or treatment as possible," and (c2) "I usually wait until I have an illness or health problem and then take steps or actions to treat it" vs. "I usually take steps or actions in advance to prevent an illness or health problem." Responses to these six statements were then averaged together to create an overall score that ranged from '1' (strong preference for natural approaches to medicine, minimal medical intervention, and doubting of mainstream medicine) to '5' (strong preference for mainstream approaches to medicine, maximum medical intervention, and believer in mainstream medicine) (2016 (weighted): *Mean* = 3.0, *SD* = 0.8, α = *0.682;* 2018 (unweighted): *Mean = 3.1, SD = 0.8,* α = 0.703).

Table 1
Health decision-making preference dimensions and associated survey statements.

(a)	Naturalist	Technologist
(a1)	"I prefer natural ways to prevent and treat illness"	"I prefer mainstream medicine approaches to prevent and treat illness"
(a2)	"I prefer complementary or alternative medicine approaches to staying healthy and treating disease"	"I prefer science and evidence-based medicine approaches to staying healthy and treating illnesses"
(b)	**Doubter**	**Believer**
(b1)	"I am most interested in the risks and potential side effects of a recommended drug or medicine"	"I am most interested in the benefits and value of a recommended drug or medicine"
(b2)	"I usually doubt health and medical advice from doctors and experts"	"I usually trust health and medical advice from doctors and experts"
(c)	**Minimalist**	**Maximalist**
(c1)	"When sick or ill, I prefer as little medicine or treatment as possible"	"When sick or ill, I prefer as much medicine or treatment as possible"
(c2)	"I usually wait until I have an illness or health problem and then take steps or actions to treat it"	"I usually take steps or actions in advance to prevent an illness or health problem"

2.2. Dependent variables

The dependent variables were measures of flu vaccine confidence, flu vaccine hesitancy, flu vaccination history, and flu vaccination intent. The vaccine confidence items sought to measure respondents' trust in the safety, effectiveness, and benefits of flu vaccines, while vaccine hesitancy was a measure of respondents' reluctance to get the recommended flu vaccination. Vaccination history reflected the number of prior years an individual received a vaccination and vaccination intention assessed willingness to get vaccinated in the future.

Flu Vaccine Confidence was assessed with three items that asked respondents to report, on five-point scales (1 = "Not at all confident," 5 = "Very confident"), their confidence in each of the following statements: "All of the vaccines recommended for adults are safe," "All of the vaccines recommended for adults are effective," and "Your overall health will benefit from getting all the recommended vaccines for adults." Responses to these three items were then averaged together to create an index of overall vaccine confidence (2016 (weighted): *Mean* = 2.8, *SD* = 1.1, α = 0.87*;* 2018 (unweighted): *Mean* = 3.1, SD = 1.1, α = 0.89). *Flu Vaccine hesitancy* was measured with a five-point scale (1 = "Not at all hesitant," 5 = "Very hesitant") asking respondents how hesitant they were about getting recommended adult vaccines (2016 (weighted): *Mean* = 2.9, *SD* = 1.4; 2018 (unweighted): *Mean* = 2.4; SD = 1.4).

Recent Flu Vaccination History asked the respondents to indicate the number of years they received a flu vaccination during the previous three years (in 2016, whether they received a vaccination from 2013 to 2015; in 2018, from 2015 to 2017) ranging from "None" (coded as '0') to "Three" (coded as '3') (2016 (weighted): *Mean* = 1.4, *SD* = 1.3; 2018 (unweighted): *Mean* = 1.5, SD = 1.3). *Flu Vaccination Intent* was measured by asking respondents to report their likelihood of getting a flu vaccination in this flu season (e.g., this fall or winter) on five-point scales (1 = "Will definitely not get one," 2 = "Will probably not get one," 3 = "Will probably get one," 4 = "Will definitely get one," 5 = "Already got one") (2016 (weighted): *Mean* = 2.8, *SD* = 1.4; 2018 (unweighted): *Mean* = 3.2, SD = 1.5).

2.3. Data analysis

We analyzed the data using ordinary least squares (OLS) regression in R [29]. Four regressions were run where variables were entered in blocks (demographic information, flu disease impacts, flu vaccine confidence and hesitancy, and health decision-making preferences) to determine the relative explanatory power of each variable (regression coefficients) as well as the contribution of each block (incremental R^2). The first two regressions focused on vaccine confidence and vaccine hesitancy [30,31]. The final two regressions focused on flu vaccination behaviors, specifically recent flu vaccination history and future flu vaccination intentions.

3. Results

Regression coefficients and R^2 values are provided in Table 2 (2016) and Table 3 (2018). The following sections summarize these results.

3.1. Vaccine confidence and vaccine hesitancy

Average scores on our overall measure of health decision-making

Table 2
2016 regressions predicting vaccine confidence, hesitancy, history, and intent.

2016	Vaccine Confidence (N = 1001)	Vaccine Hesitancy (*N* = 998)	Vaccination History (*N* = 978)	Vaccination Intent (*N* = 1001)
Block 1: Demographics				
Gender (Male = 1; Fem. = 2)	0.04	0.24**	−0.09	−0.15*
Age	0.00	0.00	0.02***	0.02***
Race (Non-Wht. = 0; Wht. = 1)	−0.17**	−0.28**	−0.1	−0.16*
Household Income	−0.01	−0.01	0.00	−0.01
Education	−0.01	−0.13***	−0.03	0.00
R^2 (%)	2.7***	7.5***	14.5***	14.5***
Block 2: Information				
Perceived Flu Knowledge	0.22***	−0.05	0.23***	0.18**
Healthcare Recommendation (Y = 1; *N* = 2)	−0.20**	0.27**	−0.58***	−0.55***
Inc. R^2 (%)	9.4***	5.6***	17.1***	15.6***
Block 3: Flu Impacts				
Flu Seriousness	0.13**	0.06	0.16***	0.25***
Flu Spread	0.04	−0.14**	0.15***	0.11*
Inc. R^2 (%)	2.8***	1.8***	4.6***	5.3***
Block 4: Vaccine Attitudes				
Vaccine Confidence	N.A.	−0.52***	0.23***	0.31***
Vaccine Hesitancy	−0.30***	N.A.	−0.22***	−0.26***
Access Difficulty	0.16**	0.00	−0.01	−0.01
Inc. R^2 (%)	15.9***	15.4***	11.5***	15.2***
Block 5: Health Decision-Making Preferences				
Decision-Making Preferences	0.27***	−0.13*	0.13**	0.17***
Inc. R^2 (%)	3.5***	0.45*	0.49**	0.65***
Total R^2 (%)	34.3***	30.8***	48.2***	51.2***

Notes: Incremental (*Inc.*) R^2 for each variable Block is calculated by taking the difference between the R^2 of the OLS regression model including all blocks up to and including the indicated Block and the R^2 of the model including only the previous Blocks. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$: the block as a whole explained a significant amount of the variance in the model.

Table 3
2018 regressions predicting vaccine confidence, hesitancy, history, and intent.

2018	Vaccine Confidence (*N* = 1015)	Vaccine Hesitancy (*N* = 1015)	Vaccination History (*N* = 1015)	Vaccination Intent (N = 1015)
Block 1: Demographics				
Gender (Male = 1; Fem. = 2)	−0.03	0.02	-0.02	0.06
Age	−0.01***	−0.01*	0.01***	0.01***
Race (Non-Wht = 0; Wht = 1)	−0.11*	−0.22**	−0.03	−0.06
Household Income	0.00	0.00	0.00	0.00
Education	−0.02	−0.04	0.05*	0.04
R^2 (%)	0.70	3.3***	8.1***	7.3***
Block 2: Information				
Perceived Flu Knowledge	0.14**	−0.01	0.19**	0.18**
Healthcare Recommendation (Y = 1; N = 2)	−0.20***	0.11	−0.64***	−0.59***
Inc. R^2 (%)	9.7***	6.0***	16.8***	15.6***
Block 3: Flu Impacts				
Flu Seriousness	0.09*	−0.06	0.17***	0.21***
Flu Spread	0.04	−0.07	0.16***	0.16***
Inc. R^2 (%)	3.6***	3.2***	5.4***	6.3***
Block 4: Vaccine Attitudes				
Vaccine Confidence	N.A.	−0.73***	0.24***	0.34***
Vaccine Hesitancy	−0.39***	N.A.	−0.24***	−0.32***
Access Difficulty	0.10*	0.02	−0.06	-0.15*
Inc. R^2 (%)	31.8***	32.1***	13.7***	20.5***
Block 5: Health Decision-Making Preferences				
Decision-Making Preferences	0.41***	−0.14**	0.00	0.04
Inc. R^2 (%)	6.6***	0.4**	0.0	0.0
Total R^2 (%)	52.4***	45.0***	44.0***	49.7***

Notes: Incremental (*Inc.*) R^2 for each variable Block is calculated by taking the difference between the R^2 of the OLS regression model including all blocks up to and including the indicated Block and the R^2 of the model including only the previous Blocks. *p < 0.05, **p < 0.01, ***p < 0.001: the block as a whole explained a significant amount of the variance in the model.

preference were significantly associated with both flu vaccine confidence and hesitancy levels (Table 2 and Table 3). Specifically, average overall health decision-making preference scores were positively correlated with vaccine confidence levels and negatively correlated with vaccine hesitancy levels, thus supporting *H1a* and *H1b*. Not surprisingly, a reduction in vaccine hesitancy was associated with higher vaccine confidence and vice versa (Table 2, Table 3). Many demographic variables also were significant predictors of both vaccine confidence and vaccine hesitancy in 2016 (Table 2), although patterns of demographic variable significance differed between the two dependent variables. In 2018, however, the demographic block was only significantly correlated with vaccine hesitancy, despite the age and race variables individually being significant predictors of both vaccine confidence and vaccine hesitancy (Table 3). In both years, lower levels of flu vaccine confidence were reported by White respondents compared to non-White respondents (specifically, in 2016, Black non-Hispanic (~11.24 % of sample) and in 2018, Hispanic (~15.49 % of sample)). In 2018, our results indicate lower vaccine confidence with increasing age.

t-tests showed no significant difference in hesitancy by gender (2016 (weighted): $p = 0.28$; 2018 (unweighted): $p = 0.85$); however, after adjusting for the other factors, our regression analysis indicated that hesitancy was higher among female respondents than among male respondents in 2016 (not significant in 2018). Hesitancy was lower among White respondents compared to non-White respondents in both years (2016: Black non-Hispanic (~11.24 % of sample) and "Other" non-Hispanic (~2.38 % of sample); 2018: Black non-Hispanic (~10.49 % of sample) and Hispanic (~15.49 % of sample)), and hesitancy level declined as education level increased in 2016 and with increased age in 2018.

Believing oneself to be informed about the flu vaccine and receiving a doctor recommendation to get a flu vaccine were both correlated with higher levels of reported vaccine confidence in both years ("*Block 2: Information*" Table 2 and Table 3), while receiving a recommendation from a doctor was associated with lower levels of reported hesitancy in 2016 (Table 2; not significant in 2018). In both 2016 and 2018, vaccine confidence was higher among those who perceived a higher negative impact of flu illness on one's life ("*Flu seriousness*"); however, there was no relationship between perceived flu illness impact and vaccine hesitancy. The belief that one was likely to pass the flu along to others ("*Flu Spread*") was unrelated to confidence in both years but was associated with lower hesitancy levels in 2016. Unexpectedly, individuals reporting difficulty in getting a flu vaccine ("*Access Difficulty*") — most often citing barriers such as cost, time, provider availability, insurance coverage, and transportation — also reported higher vaccine confidence in both years.

3.2. Recent Flu vaccination history and intention

The analyses produced mixed results with respect to *H2 (Health decision-making preference scores are positively correlated with the number past vaccinations and likelihood of future vaccination)*. In the 2016 data, average scores on the overall measure of health decision-making preferences were significantly associated with recent flu vaccination behavior ("*Vaccination History*") and intent to receive a flu vaccination in the coming flu season (Table 3). In 2016, those respondents with a higher average health-decision making preference score reported receiving more flu vaccinations in the past three years and a higher intention to receive a flu vaccination in the coming season than those with lower average scores. Overall average score on the health decision-making preference measure was not a significant predictor of either behavioral outcome in 2018.

In both data sets, demographic variables were more strongly related to the behavioral outcomes, *Vaccination History* and *Vaccination Intent*, relative to scores on the vaccine confidence and vaccine hesitancy measures. Demographic variables explained approximately 14 % of the variation in recent flu vaccination behavior and future vaccination intention in 2016, and approximately 7–8 % of the variation in *Vaccination Intent* in 2018. In the 2016 data, age was not a significant predictor of vaccine confidence and hesitancy outcomes (Table 2), but it was predictive of recent vaccination behavior and intention outcomes. Older individuals are more likely to report a higher number of flu vaccinations in the previous three years and were more likely to score high on the vaccination intention scale. Unlike with our measures of vaccine confidence and vaccine hesitancy, race and ethnicity were not significant predictors of past vaccination in 2016 or either behavioral outcome in 2018 (Table 3). We note, however, that Asian non-Hispanic respondents (~3.43 % of sample) were more likely than White respondents to report an intention to vaccinate in the future in 2018.

Both flu vaccination-related information variables – receiving a recommendation from one's doctor or healthcare provider ("*Healthcare Recommendation*") and believing oneself to be more informed about flu and the flu vaccine ("*Perceived Flu Knowledge*") were positively related ("Yes" ranked higher for response to receiving doctor recommendation) to both behavioral outcomes. Perceived severity of flu illness ("*Flu Seriousness*") and perceived likelihood of transmission ("*Flu Spread*") were also significant predictors of behavioral outcomes.

Flu vaccine confidence was a strong, positive predictor of both flu vaccination history and future flu vaccination intentions, while hesitancy was negatively correlated with both behavioral outcomes (Table 2 and Table 3). The perceived difficulty of receiving a flu vaccination ("*Access Difficulty*") was not related to either behavioral outcome measure in 2016, but there was a significant correlation in 2018 with vaccination intent where participants who perceived difficulty in obtaining a vaccine were less likely to receive a flu vaccination in the upcoming season.

4. Discussion

As adult flu vaccination coverage remains well below the 70 % target of the Department of Health and Human Services' Healthy People 2030 program, increasing flu vaccination rates has become a major priority for the CDC, influenza and adult vaccination advocates, and health care providers. Increasing flu vaccine confidence and acceptance, however, may depend on a better understanding of vaccination facilitators and inhibitors [20]. This includes identifying and examining new constructs and measures to find additional or better potential correlates of flu vaccine confidence, hesitancy, past vaccination behavior and vaccination intention. In this work, we examined whether scores on an overall measure of health decision-making preferences were associated with (a) vaccine confidence and hesitancy toward influenza vaccination, (b) recent flu vaccination history, and (c) flu vaccination intentions for the upcoming flu season.

Frameworks such as the Theory of Planned Behavior [32], and Protection Motivation Theory [33], and communication strategies such as the 7C's of Communication [34], which consider information processing, subjective norms, self-efficacy and disease and treatment perceptions as influencers of health behaviors, have not explicitly considered heuristics, or decision-making defaults –a unique attribute of the "Medical Mind" framework. Broad preference measures and predispositions, such as elaborative processing [35,36], need for humor [37], deference to scientific authority [38,39], and moral foundations [40,41], among others, have proved valuable for understanding how audiences form opinions about issues ranging from politics to science to advertising and marketing content. This study's analyses indicate there is value in examining, and continuing to examine, health decision-making preferences and their relationship to key vaccination outcomes. Importantly, the analyses were performed using data from a pair of nationally representative population samples of U.S. adults that allowed for multiple assessments of this new construct and our measure. By using the same sampling procedure and overall respondent pool, we were able to assess the consistency of the survey instrument over two different distinct flu seasons. Both the 2016 and 2018 health survey data analyses found respondents with higher health decision-making preference scores had higher levels of vaccine confidence and lower levels of vaccine hesitancy (i.e., *H1b*). Additionally, the 2016 data analyses found the health decision-making preference scores positively correlated with more reported flu vaccinations in the past three years and greater intention for the coming season (i.e., *H2b*). The same association with 2018 data was not found, and this was not the only inconsistency relative to the 2016 data.

In line with previous research [16,17,20], we found physician recommendations to correlate positively with flu vaccination intentions and past vaccination behaviors in both 2016 and 2018 although, interestingly, we did not detect a significant correlation with vaccine attitudes in 2018. Though there was a positive association between *Healthcare Recommendation* and *Vaccine Confidence*, our analysis of 2018 data failed to detect an association between receiving a physician recommendation to get a flu vaccination and lower hesitancy scores. As discussed in more detail later in this section, this may be the result of the differences in sampling weight data availability between the 2016 and 2018 data and may suggest that further refinement of the instrument is needed to increase consistency.

Overall, the results show that individuals with a higher health decision-making preference score held more favorable attitudes toward flu vaccines and had both a stronger history of receiving the flu vaccine and a greater likelihood of receiving it in the future. Although there was inconsistency in the analysis results between the data sets in this study, there is still much potential in using information about decision-making preferences in vaccination education and communication. For instance, those creating flu vaccination campaigns could assess overall health decision-making preferences among hesitant and/or sub-populations with relatively low influenza vaccination rates (e.g., 18 to 34-year-olds) to identify their overall and specific medical and treatment preferences. This information, in turn, could be used to inform framing of core flu vaccination messages. For example, if a sub-population is hesitant about flu or other adult vaccination because they have a "minimalist" approach to health and medicine, communication and messaging approaches that frame vaccines as being in line with a minimalist preference could increase adoption in this sub-population – e.g., getting a flu – or other recommended vaccination - is a good way to avoid the often extensive and longer treatment needed if you become severely ill or hospitalized. Conversely, for hesitant sub-populations with a "maximalist" preference, it might be beneficial to highlight the preemptive nature of vaccines—as another beneficial step in taking a proactive approach to one's health. Similarly, sub-populations who have low confidence and/or high hesitancy to influenza vaccination because they prefer "natural" approaches to medicine might benefit from learning about the natural processes that occur in one's body when they encounter a weakened version of the flu [42–44]. Individuals with a "technology" orientation might respond to hearing about mRNA vaccines and advances in vaccine delivery systems [45]. Finally, if "doubters" focus on the side effects of treatment rather than the treatment benefits, a careful explanation of the possible side effects, including their relative infrequency in the population might be compelling. Conversely, "believers" may be more interested in learning about the short- and long-term benefits of getting a flu vaccine on their overall health, with side effects taking up a much smaller proportion of the overall conversation.

We live in a complex, multi-faceted and dynamic media environment that facilitates the creation and maintenance of "echo chambers". Echo chambers may emerge through algorithmic content targeting or within ideologically homogeneous social media groups [46,47]. Echo chambers pose a challenge to public health communication, as they can reinforce attitudes and beliefs that diverge from public health recommendations [46,48]. At the same time, near-unlimited information access can produce "information overload", leading to fatigue and greater reliance on cognitive heuristics when making health decisions [49,50]. Addressing both echo chamber dynamics and information fatigue by framing public health messaging in ways that resonate with the decision-making preferences of different audiences may provide a novel avenue for influencing preventive health behaviors in directions that support public health security.

This study involved an assessment of the health decision-making preference ("Medical Mind") concept only in the context of adult flu vaccine confidence, hesitancy, past vaccination behavior and future vaccination intention. As such, there remains the need for a broader look into its value into understanding adult or parent/caregiver confidence, hesitancy, behaviors, and intentions with other vaccines and vaccination recommendations. We recommend testing messages that fit the health decision-making preferences of different audiences to determine whether matching message characteristics with preferences can reverse the association between current health communication efforts and increased parental misperceptions or reduce vaccination intention [51].

We also only examined the relationship between a cumulative health decision-making preference measure—calculated as the average of responses to six survey items—and vaccination-related outcomes. However, there is value in exploring the individual relationships between an overall score of each sub-dimension ('*Naturalist–Technologist*,' '*Doubter–Believer*,' and '*Minimalist–Maximalist*') and vaccination outcomes. This could strengthen understanding of the facilitators and barriers to high confidence and vaccination acceptance and improve broad communication strategies (e.g., campaigns) as well as provider-patient interpersonal communication.

The structure of the health decision-making measure – being a measure of multidimensional decision-making – lends itself to additional applications outside of the narrow context of influenza vaccination, including vaccines for other diseases, non-vaccine related interventions, and medical screening procedures. We conducted a single test in the context of vaccination attitudes and flu vaccination behaviors, but a broader investigation into other types of vaccinations and other health interventions is warranted to assess the utility range of the measure. We could also explore refining specific survey items used to measure the concept since our measure had reliability that was close to but did not always achieve the 0.70 Cronbach's alpha threshold for reliability ($\alpha = 0.68$ *(2016)*, $\alpha = 0.70$ *(2018)*).

While *Vaccine Confidence* was measured with a set of three items, *Vaccine Hesitancy*, *Vaccination History*, and *Vaccination Intent* were all single-item measures, thereby making it impossible to assess or control for random measurement error in the regression models. However, it is not unreasonable to assume that any potential random error in our single-item measures would actually serve to weaken the relationships we report here. In other words, we have likely under-reported rather than over-reported significance in the findings of our models. Furthermore, scholars have argued for the validity of single-item.

measures for concepts that are generally characterized by high levels of internal consistency [52], a case that can be reasonably made for our measures of vaccination behaviors.

Our survey instrument relied on self-report items to measure things like future flu vaccination intentions, previous flu vaccination behaviors, and overall confidence and hesitancy in vaccines. It is possible some participants did not correctly recall or honestly respond to items due to social desirability or other biases [53]. There is also the matter of individual comprehension and interpretation of the survey questions and measures which may have basis in a number of factors including culture, past experiences, and question-response structure [54–56]. These types of concerns are common, however, across all self-reported data collection methods.

Data availability varied between surveys, particularly with respect to sampling weights. The unweighted results of 2016 (not shown) were not significantly different from the weighted results. In addition, the relationships between vaccine confidence and vaccine hesitancy in 2016 and 2018 were consistent with previous findings [57,58], thus adding confidence to the use of the 2018 data and interpretation analysis results.

However, given the inconsistencies in the relationships between predictive features and attitudinal and behavioral outcomes between 2016 and 2018, a longer longitudinal examination would also be helpful to determine whether the relationships between health decision-making preferences and vaccination-related outcomes, including those used in this study, are generally stable over time. It is possible that the differences observed between 2016 and 2018 reflect changes in the health and vaccination culture landscapes that were not included here. Flu seasons vary in their timing, severity, and duration [59,60], possibly providing a different reference from which individuals shape their views on disease and vaccination and thus survey responses from year to year. In particular, the 2017–2018 flu season ranked higher in severity than the previous seasons [60]. Similarly, the shift from a Democratic to a Republican administration between 2016 and 2018 likely contributed to changes in the cultural climate surrounding healthcare and vaccines, thus influencing vaccine-related attitudes and behaviors [61–64].

A challenge that affects cross-sectional survey research relates to the issue of causality. The analyses reported here assumed that factors such as how confident or hesitant one is about vaccines influences their vaccination behaviors. Unfortunately, the cross-sectional nature of our data means that we cannot rule out alternative causal orders. Despite these limitations, we believe this work provides an important perspective on a new and potentially important indicator of one's health: health decision-making preferences. Our work suggests that understanding variation in general health decision-making preferences can be an important contributor to understanding why flu vaccination rates have been impervious to improvement.

Author contributions

All authors attest they meet the ICMJE criteria for authorship**.**

J.M.D., P.R., M.A.C. and G.J.N. were involved in the conceptualization of the project. K.M.A., M.A.C. and G.J.N. participated in data curation, investigation, developing the models and methods used in the study and preparing the initial draft of the manuscript. K.M.A. and M.A.C. lead the application of statistical methods to analyze the data. All authors read, revised and approved the final draft of the manuscript.

CRediT authorship contribution statement

Kerri-Ann M. Anderson: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation. **Glen J. Nowak:** Writing – review & editing, Writing – original draft, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Michael A. Cacciatore:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Pejman Rohani:** Writing – review & editing, Funding acquisition, Conceptualization. **John M. Drake:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: John M. Drake, Ph.D. reports financial support was provided by National Science Foundation. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The survey data analyzed in this study are available from the authors upon reasonable request. The code used for this analysis has been made publicly available in the Anderson_Flu_Vaccine_Decision_Making_Preferences repository at https://github.com/PandemicSystems/Anderson_Flu_Vaccine_Decision_Making_Preferences.git

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