MAJOR ARTICLE

Subjective and Objective Risk as Predictors of Influenza Vaccination during the Vaccine Shortage of 2004–2005

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Background. We aimed to identify the role of objective risk status and subjective risk beliefs in influenza vaccination decisions during the recent rationing of influenza vaccine.

Method. A random sample of 300 Americans, obtained through random-digit dialing, was interviewed regarding influenza vaccination practices and beliefs in September 2004 and again in March 2005.

Results. One-half of individuals at high risk of influenza did not know that they were at high risk and, therefore, were not vaccinated. Respondents at high objective risk were more likely to report having been vaccinated than respondents who were not at high objective risk (36% vs. 6%, respectively; odds ratio, 8.31; 95% confidence interval, 3.65–18.88). However, a more powerful predictor of self-reported vaccination was subjective risk (64% vs. 7%, respectively; odds ratio, 24.02; 95% confidence interval, 12.18–48.09). Subjective risk fully mediated the relationship between objective risk and vaccination. Other predictors of vaccination included physician recommendation, habit, prior vaccination intention, belief that the influenza vaccine is safe and effective, perceived likelihood of getting influenza, and trait neuroticism.

Conclusion. Health communication efforts must be more effective in persuading adults with chronic illness and individuals in contact with persons at risk that they should be vaccinated against influenza.

An estimated 36,000 people in the United States die each year of influenza-related illness [1]. Therefore, increasing influenza vaccination rates among high-risk groups is a public health priority [2]. During the influenza vaccine shortage of 2004–2005, the Centers for Disease Control and Prevention (CDC) granted 3 groups of adults the highest priority for vaccination because of the risk that influenza posed to those individuals or to people in their care. High risk groups included older adults (age, ⩾65 years) and persons aged 18–64 years who had chronic health conditions or who were living in long-term care or nursing facilities. Individuals who had regular contact with high-risk adults or children were the third high-priority group, one we will also consider high risk for the purposes of this article.

During the influenza vaccine shortage, the CDC had mixed success in encouraging high-risk individuals to become vaccinated. More than 60% of elderly adults were vaccinated, whereas only 26% of younger adults at high risk and 36% of persons with regular contact with either of these 2 groups were vaccinated [3]. By comparison, 10% of healthy adults with no risk factors were vaccinated against influenza. These findings show success in persuading older adults to be vaccinated but much less success with other high-priority groups.

The present study sought to identify the reasons why high-risk individuals were and were not vaccinated against influenza during the vaccine shortage. Although previous research shows that modifiable factors, such as higher perceived likelihood of getting influenza [4, 5], are associated with higher rates of influenza vaccination, the data are largely cross-sectional; few longitudinal studies of influenza vaccination behavior have been published [6–9]. Some randomized, controlled trials or interventions have been shown to increase influenza vaccination, but these have relied on policy or

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environmental changes, such as financial incentives, reminder systems, and standing orders in patients' medical charts [10–15]. These trials have typically not attempted to influence the directly psychological variables, such as perceived risk, that may be important mediators of vaccination behavior [10, 12, 16, 17].

To provide a basis for future health communication programs, the present study examined the role of psychosocial factors in predicting influenza vaccination behavior. Of particular concern was whether people at high objective risk were aware of their risk status. We present data from a panel study of residents of the United States who were interviewed just before the beginning of the influenza season of 2004–2005 (before the vaccine shortage was announced) and again at the end of the influenza season.

METHODS

Sample selection. We sought to interview a national probability sample of adults about influenza and influenza vaccination. For this reason, we screened out individuals who had not heard of influenza or "the flu." Because phone interviews often oversample women, we established a quota such that the percentage of female respondents was not >60% at time 1. We used random-digit dialing to obtain a proportional probability sample of households in the United States with telephone service. The study received institutional review board review and approval.

Procedure. We interviewed 400 participants by phone in September 2004 and completed interviews with 300 of them again in March 2005. The initial panel of interviews was completed before the announcement that there would be a national shortage of influenza vaccine [18]. Interviewers received training on the survey and were monitored regularly to assure the quality of the interviews. Responses to the survey were entered into a computer-assisted telephone interviewing system by the interviewer. To maximize response rates, working, nonbusiness numbers were dialed a minimum of 12 times if no answer was received, and days and times were varied for callbacks.

Instrument. The survey for time 1 consisted of questions about past influenza vaccination behavior, intention to be vaccinated during the coming influenza season, many of the risk characteristics that the CDC later used to establish priority for influenza vaccination (e.g., age and chronic health conditions), other demographic variables, trait neuroticism (a general personality trait characterized by negative feelings and heightened aversion to negative stimuli [19]), and beliefs about influenza and the influenza vaccine. The survey for time 2 consisted of questions about influenza vaccination status during the 2004–2005 influenza season, reasons for vaccination or nonvaccination, changes in risk status according to CDC-defined risk characteristics (including role as a caretaker for high-risk individuals in the time since last interviewed), and the influenza vaccine shortage. The psychosocial constructs were selected on the basis of theories of health behavior [20, 21], empirical findings [5], and in-depth interviews. Qualitative interviews were conducted with a convenience sample of 57 participants from Vermont and South Carolina that was stratified by age, education, race, and rural/urban dwelling. The interviews were transcribed and coded for thematic elements, and these themes guided our selection and wording of survey items. The draft survey was pilot-tested with 10 adults to assess their comprehension of the item wording, and then the survey was revised. The final survey was again tested with a sample of 10 randomly dialed respondents; items that were difficult for interviewers to read or for participants to understand were again revised.

Measuring objective and subjective risk. Objective risk was operationally defined as membership in 1 of the groups of adults the CDC recommended as having priority for influenza vaccination. We first attempted to place respondents into 1 of 3 mutually exclusive high "objective" risk groups. The first 2 groups were "aged ⩾65 years" or "aged 18–64 years with a qualifying health condition." The CDC stipulated qualifying health conditions as pregnancy, chronic heart or lung conditions, metabolic disease, chronic kidney disease, or a weakened immune system [18]. Respondents not included in 1 of the first 2 groups were evaluated for inclusion in the "in regular contact with an at-risk person" group. Respondents not included in any high-risk group were placed into the "low-risk adults" group. Subjective risk was determined by respondents' answers to the question, "Despite the shortage, the government recommended that people in certain categories should definitely get vaccinated. Do you believe that you were in 1 or more of those categories?" with "yes" coded as high subjective risk and "no" coded as low subjective risk. The answers of the few respondents who volunteered "maybe" or "don't know" were coded as low subjective risk.

Data analyses. Predictors of vaccination were examined using logistic regression. The analyses employed a critical α value of .05. Because none of the demographic characteristics shown in table 1, other than age, were related to vaccination behavior, we present only analyses unadjusted for demographic characteristics. Data were analyzed using the binary logistic regression procedure in SPSS software, version 13.0 (SPSS).

RESULTS

Participants. Figure 1 shows how the sample was derived. Four hundred participants completed the survey at time 1. This reflects a response rate of 62% (400 of 641 subjects) and a cooperation rate of 71% (400 of 564). Of those who completed the survey at time 1, a total of 300 persons were successfully interviewed again at time 2, reflecting a response rate of 75% (300 of 400 subjects) and a cooperation rate of 98% (300 of 307). The effective response rate for time 2 with respect to the

Table 1. Characteristics of influenza vaccination study participants.

Characteristic	Nonresponders to survey at follow-up (n = 100)	Responders to survey at follow-up (n = 300)	Responders who were not vaccinated (n = 226)	Responders who were vaccinated (n = 74)
Sex				
Male	47 (47)	116 (39)	91 (40)	25 (34)
Female	53 (53)	184 (61)	135 (60)	49 (66)
Hispanic				
No	90 (90)	275 (92)	205 (91)	70 (95)
Yes	10 (10)	25 (8)	21 (9)	5 (5)
Race				
White	74 (74)	252 (84)[a]	185 (82)	67 (91)
Other	26 (26)	48 (16)[a]	41 (18)	7 (9)
Education				
No college degree	61 (61)	182 (61)	133 (59)	49 (66)
College degree	39 (39)	118 (39)	93 (41)	25 (34)
Yearly income				
<$50,000	55 (55)	145 (48)	108 (48)	37 (50)
⩾$50,000	45 (45)	155 (52)	118 (52)	37 (50)
Married				
No	50 (50)	126 (42)	92 (41)	34 (46)
Yes	50 (50)	174 (58)	134 (59)	40 (54)
Age, mean years ± SD	49 ± 17	50 ± 17	45 ± 15	63 ± 16[b]

NOTE. Data are no. of persons (%), unless otherwise indicated.

[a] Participation in the follow-up survey was unrelated to sex, education, income, marital status, or age. Nonresponders and responders at follow-up (March 2005) differed only by race, with white persons being more likely to respond than nonwhite persons (OR, 1.85; 95% CI, 1.05–3.32).

[b] Sex, education, income, race, and marital status were all unrelated to vaccination. Older participants were more likely to be vaccinated than were other respondents (t, 8.98 with 298 degrees of freedom; P <.001).

interviews attempted at time 1 is 47% (300 of 641 subjects), and the effective cooperation rate is 64% (300 of 471 [i.e., 300 + 164 + 7]). The demographic characteristics of the final sample are shown in table 1. Responders and nonresponders to the follow-up survey did not differ by sex, education, income, Hispanic ethnicity, marital status, or age, but they differed by race, with white persons being somewhat more likely to respond than nonwhite persons (OR, 1.85; 95% CI, 1.05–3.32).

Objective and subjective risk. We observed a large gap between membership in an objective risk group and respondents' subjective beliefs about risk. With respect to objective risk, 188 (63%) of 300 respondents were in 1 of the high-risk categories. Sixty-two respondents were aged ⩾65 years, 93 were aged 18–64 years with high-risk health conditions (including chronic illnesses and pregnancy), and 33 had routine contact with high-risk individuals but no other risk factors. However, reporting of high subjective risk (as mentioned, the belief that one was a member of 1 or more of the groups the CDC placed at highest priority for being vaccinated during the shortage, compared with being in the low priority group) was less common. Only 94 (31%) of 300 respondents believed themselves to be in a high-risk group (table 2).

Upon further examination of the correspondence between objective and subjective risk, we found that underestimating risk was common but overestimating risk was rare (figure 2). One-third of respondents (98 of 300) incorrectly perceived themselves to be at low risk despite actually being at high risk. Few persons ⩾65 years of age (12 [19%] of 62) incorrectly perceived themselves to be at low risk. However, incorrect risk beliefs were held by two-thirds of respondents in the other 2 groups: persons aged 18–64 years who were at high risk (64 [69%] of 93) and caretakers for persons at high risk (22 [66%] of 33).

Influenza vaccination. Overall, 74 (25%) of 300 respondents reported having been vaccinated between September 2004 and March 2005. All reported having received the vaccine by injection except 1 person, who received it by nasal spray. Respondents at high objective risk were more likely to report having been vaccinated than persons at low objective risk (67 [36%] of 188 vs. 7 [6%] of 112), as shown in table 2. Among the high objective risk groups, individuals aged ⩾65 years were more likely to have been vaccinated (41 [66%] of 62) than were younger adults with high risk conditions (19 [20%] of 93; OR, 7.60; 95% CI, 3.67–15.76) or respondents in regular contact

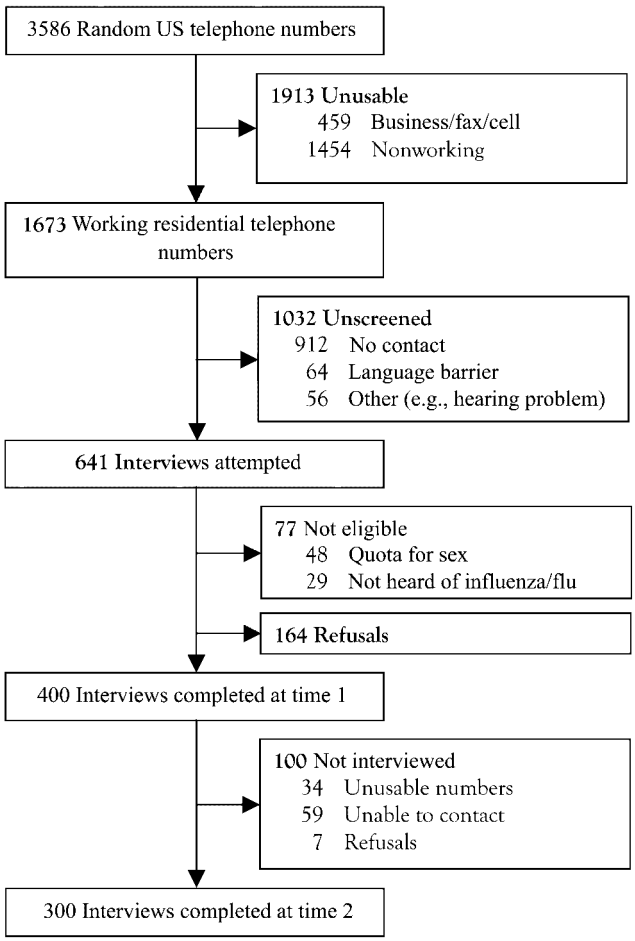

Figure 1. Characteristics of the influenza vaccination study sample.

with individuals at highest risk (7 [21%] of 33; OR, 7.25; 95% CI, 2.70–19.45). These influenza vaccination rates are very similar to the findings of a CDC study from the same time [3].

Higher subjective risk was the most powerful predictor of self-reported vaccination uptake (60 [64%] of 94 vs. 14 [7%] of 206). Other predictors were physician recommendation to be vaccinated, having had a "flu shot" in the past 2 years, intention to be vaccinated during the influenza season, perceived effectiveness of influenza vaccination, belief that influenza vaccination does not cause influenza or severe adverse effects, perceived likelihood of getting influenza, and trait neuroticism (tables 2 and 3). When expressed in standardized effect sizes [22], subjective risk was the largest predictor of vaccination ($r = 0.61$; 95% CI, 0.52–0.70), larger than objective risk ($r = 0.33$; 95% CI, 0.22–0.44) or other measures of perceived risk, perceived likelihood of getting influenza ($r = 0.30$; 95% CI, 0.19–0.40), and perceived severity of disease ($r = 0.11$; 95% CI, −0.01 to 0.22).

We examined the relationship between objective and subjective risk and self-reported vaccination to understand why individuals in high-risk groups had such low influenza vaccination rates. Risk underestimation had a consequence: only 9 (9%) of 98 persons at high objective risk who believed themselves to be at low risk reported getting vaccinated (figure 2). We examined whether subjective risk mediated the effect of objective risk on vaccination. A multiple regression analysis containing objective and subjective risk showed a robust effect of subjective risk (OR, 18.24; 95% CI, 8.52–39.03) and no effect of objective risk (OR, 2.02; 95% CI, 0.76–5.38). This finding supports the conclusion that objective risk affects vaccination only insofar as it changes subjective risk (i.e., full mediation) [23].

The commonness of erroneous risk beliefs and the negative consequences for vaccination behavior that these beliefs impart prompted us to look for predictors of risk underestimation among the high objective risk groups. Accurate subjective risk belief (i.e., that risk was high) was strongly predicted by receiving a physician's recommendation to be vaccinated (OR, 18.33; 95% CI, 6.20–54.23) but not by 2 widely used measures of perceived risk, the perceived likelihood of and the perceived severity of getting influenza. Other predictors were having had an influenza vaccination in the past 2 years (OR, 3.48; 95% CI, 1.87–6.52), intention to be vaccinated (OR, 1.49; 95% CI, 1.25–1.79), and belief that influenza vaccination is effective (OR, 2.01; 95% CI, 1.28–3.15).

Effect of shortage on vaccination rates. We now turn to how the influenza vaccine shortage affected decisions to be vaccinated. Seventy-one (24%) of 300 respondents said the shortage discouraged them from being vaccinated, 10 (3%) of 300 said that it encouraged them to be vaccinated, and 219 (73%) of 300 said it had no effect. Individuals at objectively high risk were slightly more likely to report that they had been discouraged from being vaccinated (22 [20%] of 112; low objective risk vs. 49 [26%] of 188; high objective risk), but this difference was not significant (OR, 1.44; 95% CI, 0.82–2.55). Persons who believed the vaccine shortage had discouraged or encouraged them to be vaccinated were, respectively, less and more likely to have been vaccinated than persons who said the shortage had no effect on their vaccination decision (table 2). Indeed, only 8 (11%) of 71 respondents who said that the vaccine shortage discouraged them said that they proceeded to get vaccinated. In response to an open-ended question about why unvaccinated respondents had not received an influenza vaccination, the most commonly stated reason was the vaccine shortage, given by 21 (20%) of 105 respondents at low objective risk and 45 (37%) of 121 at high objective risk (OR, 2.37; 95% CI, 1.30–4.33).

In addition to having their vaccination decisions affected, some respondents may have tried to get vaccinated and found no vaccine available. Although individuals who made a previous, failed attempt to be vaccinated during the time of the study were more likely to report having been vaccinated (OR,

Table 2. Continuous predictors of receiving influenza vaccination.

Predictor	No. of persons vaccinated/total no. of persons in predictor category (%)	Unadjusted OR (95% CI)
Objective CDC risk[a]		
Low	7/112 (6)	1.0
High (all categories)	67/188 (36)	**8.31 (3.65–18.88)**
In contact with a high-risk person	7/33 (21)	**4.04 (1.30–12.53)**
Aged 18–64 years with a high-risk condition	19/93 (20)	**3.85 (1.54–9.63)**
Aged ⩾65 years	41/62 (66)	**29.29 (11.57–74.11)**
Subjective CDC risk[b]		
Low	14/206 (7)	1.0
High	60/94 (64)	**24.02 (12.18–48.09)**
Received physician's recommendation to be vaccinated		
No	38/251 (15)	1.0
Yes	36/48 (75)	**16.82 (8.03–35.21)**
Made a failed attempt to get vaccinated		
No	62/271 (23)	1.0
Yes	12/29 (41)	**2.38 (1.08–5.25)**
Vaccine shortage affected plans to get vaccinated		
Discouraged	8/71 (11)	**0.34 (0.15–0.76)**
No change	59/219 (27)	1.0
Encouraged	7/10 (70)	**6.32 (1.58–25.28)**
Engaged in other influenza-protective behaviors[c]		
No	36/150 (26)	1.0
Yes	35/148 (24)	0.88 (0.52–1.49)
Ever had influenza		
No	19/65 (29)	1.0
Yes	55/231 (24)	0.76 (0.41–1.40)
Vaccinated against influenza in last 2 years		
No	7/154 (5)	1.0
Yes	67/146 (46)	**17.81 (7.80–-40.64)**
Belief that influenza is caused by a virus		
No/don't know	15/56 (27)	1.0
Yes	57/236 (24)	0.87 (0.45–1.69)
Belief that influenza vaccination can cause a person to get influenza		
No	45/134 (33)	1.0
Yes	19/143 (13)	**0.30 (0.17–0.55)**

NOTE. The first 6 variables were assessed at follow-up in March 2005, when vaccination was also assessed. The remaining variables were assessed 6 months earlier. Bolded ORs are statistically significant ($P < .05$). CDC, Centers for Disease Control and Prevention.

[a] Respondent was in ⩾1 of the CDC priority categories for vaccination: aged ⩾65 years, aged 18–64 years with a chronic health problem, or a person in regular contact with a high-risk person.

[b] The survey question read, "Despite the [influenza vaccine] shortage, the government recommended that people in certain categories should definitely get vaccinated. Do you believe that you were in one or more of those categories?"

[c] Included washing hands thoroughly after shaking hands, avoiding people who seemed to have the flu or are otherwise sick, and eating a healthy diet.

2.38; 95% CI, 1.08–5.25), this may be because they were more determined to get vaccinated in the first place. A more informative way to characterize the effects of the shortage on vaccination behavior is to examine whether failed vaccination attempts stymied people's intentions to get vaccinated. For high-risk persons who did not make a failed attempt, those with higher intentions to get vaccinated were more likely to have done so by follow-up (OR, 2.32; 95% CI, 1.74–3.09), as one would expect. However, individuals who made a failed attempt showed no relationship between intention and sub-

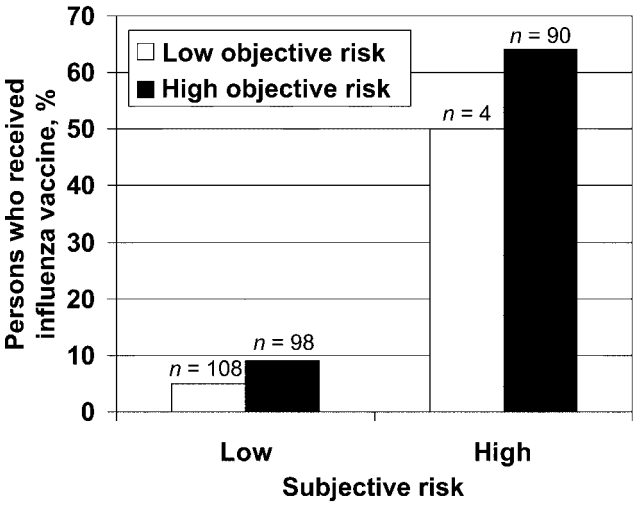

Figure 2. Relationship between risk of influenza and receipt of vaccination.

sequent vaccination (OR, 0.89; 95% CI, 0.44–1.83), suggesting that their good intentions to be vaccinated had been thwarted.

DISCUSSION

During the influenza vaccine shortage of 2004–2005, many people in high-risk groups (especially persons aged ⩾65 years) were aware that they were at high risk, and a greater proportion of persons who said that they were at high risk reported having been vaccinated as a result. However, the majority of individuals at high objective risk (especially younger adults who had chronic health conditions and persons caring for others at high risk) did not view themselves as being in a high objective risk group, and few reported being vaccinated.

Subjective risk was a stronger predictor of self-reported influenza vaccination uptake than membership in a high objective risk group. Furthermore, believing oneself to be a member of a high-risk group was a stronger predictor of getting vaccinated than other traditional measures of perceived risk, such as perceived likelihood and perceived severity [4]. People may find assessment of future risk particularly difficult because it requires imagining and consolidating many "what-ifs," a complex mental simulation of uncertain future events that may be influenced by multiple contingencies. In contrast, it may be far easier for people to make categorical judgments about belonging to a particular risk group on the basis of a clear recognition of their present circumstances (and to follow the unambiguous advice regarding vaccination) [24, 25]. Thus, although estimating future risk requires a judgment under uncertainty, knowing that you belong to a high-risk group can be as simple as knowing how old you are.

Health risk communication messages framed around readily identifiable risk factors, such as age may be more effective in persuading people to get vaccinated than messages framed around the likelihood of getting ill or even the severity of the consequences. Indeed, an advantage of framing health messages around readily identifiable demographic risk factors (such as age) is that it presents the opportunity for others to recognize that an individual belongs to a high-risk group and to apply social pressure to persuade that person to get vaccinated. If individuals in a high-risk group identify with their cohort, specific messages can be targeted to well-defined market segments. The importance of vaccines can thus be made easier to understand by readily identifiable high-risk cohorts.

Although shortages of various vaccines are well documented, the 2004–2005 influenza vaccine shortage in the United States

Table 3. Categorical predictors of receiving influenza vaccination.

Predictor	Mean ± SD		Unadjusted OR (95% CI)
	Nonvaccinated persons	Vaccinated persons	
Intention to be vaccinated[a]	2.43 ± 1.62	4.40 ± 1.18	**2.27 (1.81–2.85)**
Still receiving protection from previous influenza vaccination[b]	1.77 ± 0.75	1.98 ± 0.99	1.33 (0.89–1.9)
Influenza vaccination side effects are severe[b]	1.79 ± 0.71	1.42 ± 0.75	**0.44 (0.27–0.69)**
Influenza vaccination is effective[b]	2.25 ± 0.61	2.81 ± 0.64	**4.01 (2.51–6.41)**
Likely to get influenza in the next year if not vaccinated[b]	2.86 ± 1.21	3.73 ± 1.02	**1.91 (1.47–2.48)**
Influenza symptoms would be serious[b]	2.90 ± 0.69	3.07 ± 0.69	1.46 (0.97–2.21)
Antibiotics effectively treat influenza[b]	1.72 ± 0.77	1.75 ± 0.79	1.05 (0.74–1.49)
Perceived knowledge about influenza[c]	3.72 ± 0.78	3.75 ± 0.83	1.05 (0.75–1.47)
Trait neuroticism[d]	1.64 ± 0.89	1.93 ± 1.03	**1.35 (1.03–1.76)**
Days between exposure and illness	4.47 ± 4.32	4.71 ± 3.84	1.01 (.95–1.08)

NOTE. All variables were assessed during the initial interview in September 2004. Bolded odds ratios are statistically significant ($P < .05$).

[a] Based on a 5-point response scale (extremely unlikely to extremely likely).
[b] Based on a 4-point response scales (none/not at all to complete/completely/extremely).
[c] Based on a 5-point response scale (not at all to very well).
[d] Based on a 5-point response scale (strongly disagree to strongly agree).

was more severe than other recent shortages, with the distribution of only 58 million doses, compared with 70–80 million doses in each of the previous 4 years [26]. We found support for concerns that the shortage discouraged some high-risk individuals from being vaccinated [27–30]. High objective risk participants who were not vaccinated most commonly mentioned the shortage as the primary reason. This finding suggests an aspect of influenza vaccine shortages that deserves greater attention: namely, that the mere announcement of a vaccine shortage may discourage high-risk—not just low-risk—individuals from pursuing vaccination.

The study has several limitations. Although many of the study's findings are longitudinal, some rely on cross-sectional data. Because all of these data are correlational in nature, experimental work is needed to confirm the findings. Our focus on vaccination behavior (rather than mere intention to be vaccinated) as the outcome measure is a strength of the study, but this primary outcome is self-reported. Whereas an objective measure of vaccination, as from medical chart review, would increase our confidence in our findings, past research has shown that self-reported influenza vaccination is sensitive with reference to objective measures, although the specificity varies from low to near-perfect [31–34]. We selected our sample using random-digit dialing, a gold standard in public opinion research. Although this approach can lead to a more representative sample, there are some populations of particular interest that may not be reached. In the present study, we did not interview any persons in long-term care or nursing facilities, populations of particular interest on whom future researchers may wish to focus.

In sum, the findings reveal that subjective risk of contracting influenza is an important predictor of self-reported vaccination against influenza, and is even more important than objective risk. Given the lack of psychosocial interventions that are known to be effective in increasing influenza vaccination behavior (e.g., influencing psychosocial variables, such as subjective risk), the present study is important in that it offers evidence that can be used in the design of such interventions.

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