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The Social Ecological Model as a Framework for Determinants of 2009 H1N1 Influenza Vaccine Uptake in the US

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Abstract

Research on influenza vaccine uptake has focused largely on intrapersonal determinants (perceived risk, past vaccine acceptance, perceived vaccine safety) and on physician recommendation. We utilized a social ecological framework to examine influenza vaccine uptake during the 2009 H1N1 pandemic. Surveying an adult population (n=2079) in January 2010 with significant oversamples of African Americans and Hispanics, we found that 18.4% (95% CI 15.6–21.5) had gotten the 2009 H1N1 vaccine. Variables at each level of the social ecological model were significant predictors of uptake as well as of intent to get the vaccine. The intrapersonal level explained 53%, the interpersonal explained 47%, the institutional level explained 34%, and the policy and community levels each explained 8% of the variance associated with vaccine uptake. The levels together explained 65% of the variance, suggesting that interventions targeting multiple levels of the framework would be more effective than interventions aimed at a single level.

Keywords

social ecological model; vaccine; health behavior; risk communication

Background

Contrary to most health behavior theories, which focus predominantly on attitudinal variables at the intrapersonal level, the Social Ecological Model (SEM) (McLeroy, Bibeau, Steckler, & Glanz, 1988), argues that individual behavior is shaped by factors at multiple levels, including institutional, community, and policy levels in addition to intrapersonal and interpersonal levels. Although this model is widely accepted, rarely do researchers have the opportunity to examine the importance of each level in a single study of the analysis of a health behavior decision. We had the opportunity to do this during a real health crisis with a clearly defined behavioral outcome, i.e., getting vaccinated for H1N1 during the 2009 influenza pandemic in the United States (US). Limited vaccine became available in October 2009, and was recommended for target groups totaling about 160 million people (Centers for Disease Control and Prevention, 2010c) based on recommendations of the Advisory Committee on Immunization Practices (ACIP) (Centers for Disease Control and Prevention's Advisory Committee on Immunization Practices, 2009). As vaccine availability

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increased, the Centers for Disease Control and Prevention (CDC) encouraged everyone, including those aged ≥65, to get vaccinated (Centers for Disease Control and Prevention, 2010a).

The Social Ecological Model as a framework for Influenza Vaccine Acceptance

Research on the determinants of influenza vaccine uptake has focused largely on intrapersonal determinants such as perceived risk, past vaccine acceptance, and beliefs about vaccine safety, and on physician recommendation (Chapman & Coups, 1999; Cummings, Jette, Brock, & Haefner, 1979; Eastwood, Durrheim, Jones, & Butler, 2010; Maurer, Harris, Parker, & Lurie, 2009; Maurer, Uscher-Pines, & Harris, 2010c; Oliver & Berger, 1979; Quinn, Thomas, & Kumar, 2008; Schwarzinger, Flicoteaux, Cortarenoda, Obadia, & Moatti, 2010; Seale et al., 2010). In this comprehensive study of the factors correlated with vaccine uptake in the US, we utilize the SEM as an organizing framework (Figure 1) to explore the determinants of 2009 H1N1 influenza vaccine uptake with data from the 2009 H1N1 pandemic. In the following sections, we will discuss each level in the SEM and describe the evidence for determinants of vaccine uptake at that level.

Intrapersonal level

Attitudes and beliefs are the typical variables measured for the intrapersonal level of influence. In the case of H1N1 vaccination, perceptions of susceptibility to the disease, effectiveness of the behavior (getting the vaccine) in affording protection against the disease, and barriers to vaccination are expected to impact vaccine uptake based on such behavioral theories as the Health Belief Model (Rosenstock, 1990) and Protection Motivation Theory (Maddux & Rogers, 1983). Beliefs about the safety of vaccines, if negative, can act as a barrier (Chapman & Coups, 1999; Oliver & Berger, 1979), or, if positive, can promote vaccination (Chapman & Coups, 1999; Cummings et al., 1979; Maurer, Uscher-Pines, & Harris, 2010b; Oliver & Berger, 1979). Trust in the government is another belief that impacts engagement in a government-recommended health behavior (Blanchard et al., 2005; Quinn, Kumar, Freimuth, Kidwell, & Musa, 2009). One measure, which is behavioral rather than attitudinal, but is nonetheless an intrapersonal variable correlated with vaccination, is past vaccine uptake: those who get the seasonal flu vaccine regularly are more likely to get a new vaccine. Regular or recent seasonal flu vaccine uptake was correlated with not only H1N1 vaccine uptake and intention to accept the vaccine during the 2009 pandemic in multiple studies in Australia, France, and the US (Eastwood et al., 2010; Maurer et al., 2009; Quinn et al., 2009; Schwarzinger et al., 2010; Seale et al., 2010; Setbon & Raude), but also in many studies examining the correlates of influenza vaccine uptake in general (see (Chapman & Coups, 1999) and references therein).

Knowledge about the issue may be an important intrapersonal influence on behavior. In a vaccine shortage, perceived membership in a priority group for vaccination could impact uptake more than *actual* membership in a priority group (Brewer & Hallman, 2006). We will test the relation between perception (an intrapersonal level variable) with actual membership in a priority group (a policy level variable) and its impact on vaccine uptake during the H1N1 pandemic.

Interpersonal level

In the SEM, the interpersonal level refers to social influence from friends and family and norms within social networks (McLeroy et al., 1988). Interpersonal relationships have major influences on health behaviors including consulting a healthcare provider and cancer screening (Ashida, Wilkinson, & Koehly, 2010; Kinney, Bloor, Martin, & Sandler, 2005;

Pasick et al., 2009). In the context of vaccine uptake, people who believe that family and friends want them to be vaccinated are more likely to accept the vaccine (Cummings et al., 1979; Nowalk, Zimmerman, Shen, Jewell, & Raymund, 2004; Oliver & Berger, 1979; Zimmerman et al., 2003). Furthermore, as the number of people getting the vaccine in one's environment increases, representing the social norm, vaccine uptake increases (Chapman & Coups, 1999).

Institutional level

Institutions include healthcare organizations, ranging from primary care physicians to health centers, which provide information on influenza and vaccines. Multiple studies have shown that physician recommendations increase vaccine acceptance (Cummings et al., 1979; Eastwood et al., 2010; Madhavan, Borker, Fernandes, Amonkar, & Rosenbluth, 2003; Quinn et al., 2009; Schwarzinger et al., 2010). This determinant assumes access to and contact with a regular primary care provider, a resource that is inequitably distributed, based on race/ethnicity, income, and education (Agency for Healthcare Quality and Research, 2008).

Community level

At the community level, multiple factors could impact vaccine uptake, including presence of the disease in one's community. The social context of risk perception is often ignored but is probably important for an infectious disease where one may worry about infecting others as well as getting sick themselves. The social amplification of risk framework (Kasperson, 1988) supports the importance of collective social dynamics in shaping risk perception; we will test the impact of such community-level risk on vaccine uptake.

Policy level

Membership in a vaccine priority group is expected to foster vaccine uptake (Brewer & Hallman, 2006). Access to health insurance, as determined by federal policies, could impact vaccination rates: insurance coverage for immunization is a significant predictor of vaccine uptake (Madhavan et al., 2003). It is sometimes argued that health insurance coverage is a personal choice and should not be viewed as an issue of access. The uninsured are, however, overwhelmingly also the poor, the low-wage-earners, and those without children, who do not qualify under Medicaid's stringent standards (Henry J. Kaiser Family Foundation, 2003). From this standpoint of the social determinants of health behaviors, we view health insurance coverage as an issue of access in this study. Policies governing access to health insurance often determine access to vaccine and are therefore important in vaccine decision making. In the 2009 H1N1 pandemic, federal funding covered the costs of H1N1 vaccine and its administration at public health departments, mass vaccination clinics, and through commercial community vaccinators effectively removing the need for insurance (Centers for Disease Control and Prevention, 2009) if people were willing to get vaccinated at these venues. Thus, during the pandemic, we hypothesize that access to health insurance would not have been a barrier to vaccination if people were aware of the free availability of vaccine and willing to be vaccinated at selected locations.

In this study, we examine the significance of variables in each level of the SEM in predicting H1N1 vaccine uptake by analyzing both behavior and behavioral intent during the 2009 H1N1 pandemic. We believe that given the cross-sectional nature of the study, a comparison of attitudinal determinants impacting 'having gotten the vaccine' and 'intent to get the vaccine' allows us to accurately conclude which variables are determinants of vaccine uptake. We also examine the relationship between perceived and objective membership in a priority group, and its effect on vaccine uptake; this could have important implications for risk communication with people who are recommended to get the vaccine.

A comprehensive understanding of the determinants of this primary preventive behavior could inform the choice of interventions to improve vaccine coverage.

Methods

A representative sample of the US population was randomly drawn from the Knowledge Networks (KN) online research panel, composed of approximately 50,000 people. KN uses probability-based sampling methods and the dual sampling frames of random-digit dial sampling and address-based probability sampling (utilizing the US Postal Service's Delivery Sequence File) to recruit people to the panel. Using both sample frames ensures that households without telephones and cell-phone-only households, as well as households not otherwise reachable by telephone will be included in the panel. Further, households without internet access are provided computers and internet access. Thus the panel itself is representative of 97% of the US population (http://www.knowledgenetworks.com/knpanel).

For this study, a randomly selected sample of 3689 adults aged ≥18 from the panel was invited by KN to participate. Oversamples of African Americans and Hispanics (from KN's Latino Panel) were included to facilitate comparison by race/ethnicity. The survey was fielded and administered as a web survey by KN in both English and Spanish. KN sends emails and telephone reminders to study participants to maximize participation. 2079 respondents completed the survey for a 56% completion rate. To reduce any potential effects of non-response and non-coverage biases among the study respondents, KN includes weighting variables in the data file. These incorporate design-based weights to account for the recruitment of the panelists and both panel-based and study-specific post-stratification weights benchmarked against the most recent Current Population Survey (CPS) with respect to demographic and geographic distributions of the US population aged ≥18 and for Hispanic language usage from the 2006 Pew Hispanic Center Survey. The post-stratification variables include gender, age, race/ethnicity, education, census region, metropolitan area, internet access, and primary language used. Language usage adjustments allow for the correct proportional fitting of Spanish-speaking members relative to other English-speaking Hispanic and non-Hispanic panel members. More information on the KN research panel is available from their website (http://www.knowledgenetworks.com/knpanel).

A note about the timing of our survey: though vaccine supply was unpredictable in fall, 2009, supply had stabilized by the time our survey was in the field (between January 22nd and February 1st 2010). Our survey was fielded for 10 days at a time when vaccine had been available in large quantities for weeks (Centers for Disease Control and Prevention, 2010b). We did not collect information on the date of vaccination, however, and are unable to rule out potential disequilibria caused by temporal changes in vaccine supply and communication during fall, 2009.

Survey Instrument and Measures

The questionnaire focused on attitudes and beliefs towards the 2009 H1N1 virus (identified interchangeably as swine flu) and acceptance of the H1N1 influenza vaccine, past vaccine behavior, knowledge of membership in a priority group, and access to health insurance and healthcare. KN collects demographic variables as part of their research procedures. We will outline measures used in each level of the social ecological framework below.

Intrapersonal level

The intrapersonal level included measures about attitudes toward the virus and the H1N1 vaccine, past vaccine behavior, and perceived membership in a priority group for vaccination. Three items measured perceived risk from the virus (see Table 3). An exploratory factor analysis (principal factor extraction) indicated that the three items loaded on a single factor (Cronbach's alpha=0.83). Similarly, three other items measured perceived risk from the vaccine itself. These three items also loaded on a single factor in a factor analysis (Cronbach's alpha=0.79). We thus created two scales: "Disease Risk Perception" and "Vaccine Risk Perception" (Table 3). The vaccine risk perception items gauged beliefs about vaccines in general but were flanked in the questionnaire by questions asking specifically about swine flu and the H1N1 vaccine. Intuitively, people who believe that most vaccines are not safe or that vaccines are riskier than the disease are expected to be less willing to get the influenza vaccine. A mean score was calculated for each individual for each scale. Higher values on each scale reflect increasing risk perception.

Other attitudinal measures included perceived effectiveness of vaccination: "How effective do you think the following behaviors are in protecting you (or others) from swine flu?—Getting the 2009 swine flu vaccine." Responses were dichotomized by collapsing 'not at all' and 'only a little effective' ("Not Effective"), and 'moderately' and 'very effective' ("Effective").

Perceived vaccine safety was measured using one item: "The newly developed vaccine for swine flu is safe." Responses were dichotomized by collapsing 'strongly disagree' and 'disagree' ("Disagree"), and 'agree' and 'strongly agree' ("Agree"). A scale for measurement of trust in the government's handling of the pandemic has been described elsewhere (Quinn et al., 2009). The seven items in this scale loaded on a single factor with Cronbach's alpha=0.93, Mean=2.44 (Range 1–4), SD=0.69.

One item assessed history of seasonal flu vaccine acceptance ("annually" and "most years but not all" collapsed into "Regularly;" "once or twice" and "never" collapsed into "Seldom").

Perceived membership in a priority group, i.e. "Subjective Priority" was measured using this item, "Are you in a priority group to get the swine flu vaccine first?" ("No" and "Don't know" collapsed into "No").

Interpersonal level

The interpersonal level included measures of social influence on vaccine behavior. The number of people influencing a positive vaccination decision was assessed by asking, "Do you think the following people want you to get the swine flu vaccine?—best friend, sibling(s), parent(s), spouse or partner, and daughter or son." The total number of positive responses yielded a score ranging from 0–5, labeled "size of influential network." Another question gauged perceived social norm: "How many of your friends and family got the swine flu vaccine?" ("Some," "Most," and "almost all" collapsed into "Most," compared with "Very few").

Institutional level

The institutional level included the amount of information received and influence from the healthcare provider. We assessed having a regular health care provider (yes/no) and the amount of information received from the health care provider regarding swine flu (4–point scale from 'none at all' to 'a lot'). The response to "Do you think your doctor wants you to get the swine flu vaccine?" was dichotomized as 'No/Not Sure' versus 'Yes.'

Community Level

Disease presence and perceived risk at the community level were measured using five items (Table 3). These items loaded on one factor (Cronbach's alpha = 0.79). A mean score for the items was calculated for each individual with at least four responses (Table 3) for a scale labeled "Community Risk."

Policy Level

The policy level included a measure of access to health insurance (Do you have health insurance? Yes/No). Membership in a priority group for vaccination, i.e. "Objective Priority" was computed as a dichotomous variable based on the ACIP's recommendations (Centers for Disease Control and Prevention's Advisory Committee on Immunization Practices, 2009). We asked if respondents had been told by a health professional that they had any of 9 chronic medical conditions. We gave those aged 25–64 years with a chronic condition, pregnant women, respondents aged 18–24, and those who reported being caretakers of children aged <6 months or healthcare/emergency medical services personnel a score of 1; all others got a score of 0 ('No').

Outcome Variables

Two outcome variables were used: "Have you gotten the swine flu vaccine for yourself?" (Yes/No) and "Do you intend to get the swine flu vaccination in the next month?" (Yes/No/Don't Know) (See Table 1). Those who reported "Don't Know" were left out of analysis of behavioral intent as the "Don't Know" response is conceptually distinct from "No" or "Yes;" our aim here is to compare the determinants of behavior, measured after the behavior had been carried out, with the determinants of behavioral intent.

Data Analysis

The data were analyzed with STATA 11 (StataCorp, 2009) utilizing complex survey analysis procedures (Lee, 2006). All analyses, with the exception of factor analyses and reliability calculations, were weighted to be nationally representative. We carried out a total of ten multiple binary logistic regression models. In five, we modeled H1N1 vaccine uptake as the dependent variable. In the remainder, we modeled intent to get vaccinated "in the next month" as the dependent variable. Each model included predictor variables measured at a different level of the SEM with listwise deletion, and each is adjusted for the same set of demographic covariates. Thus, we tested one model for each level of the social ecological framework using Maximum Likelihood Estimation. We examined a histogram of Pearson residuals, a quantile-normal plot of deviance, and box plots of leverage. We also compared each model with and without bootstrapping (1000 replicates) to diagnose any violation of assumptions of these logistic regression models (Efron & Tibshirani, 1994). The standard error, p-value, and confidence intervals overlapped with and without bootstrapping, showing that outliers and influential cases were not an issue. Therefore, we report the overall F-test results for the models without bootstrapping for ease of interpretation. STATA reports a t-test for each predictor in the logistic regression model with complex sampling instead of Wald chi-square or z-test; a p-value ≤ 0.05 indicated a significant finding. In addition, a McKelvey-Zavoina pseudo-R^2 is reported for each logistic regression model (McKelvey & Zavoina, 1975). Whereas there are many ways to calculate a pseudo-R^2 value in a logistic regression model, the McKelvey-Zavoina R^2 provides a value that can be interpreted in a way similar to the Ordinary Least Squares multiple regression R^2. We conducted a bivariate probit regression on H1N1 vaccine uptake and past vaccine uptake to test for correlation in the error terms for the two outcomes. McNemar's non-parametric test (McNemar, 1947) was used to determine if there was a significant difference between under- and over-estimation of membership in a priority group.

Results

Overall, 18.4% of respondents reported having received the H1N1 vaccine. 8.6% of those who had not gotten the vaccine reported that they intended to get it 'in the next month' (Table 1). Table 2 shows demographic details by H1N1 vaccine uptake. Those who got the vaccine were significantly older, and more likely to have health insurance and a regular healthcare provider than those who did not get the vaccine. Minorities and lower educated people were more likely to *intend* to get the vaccine in the next month.

Factors explaining vaccine uptake in each level of the SEM

We examined the significance of variables within each level of the social ecological framework to explain vaccine uptake in simple and multiple binary logistic regression models. Multiple logistic regression models to predict vaccine uptake by variables in each level were controlled for demographic factors (income, education, age, gender, and race). We present results from separate analyses for behavior (got the vaccine vs. did not get it) and behavioral intent (intend to get the vaccine vs. do not intend to get it) for those who had not yet received the vaccine. Given the cross-sectional nature of the data analyzed, we present the latter analysis as a comparison to test whether variables—especially attitudinal variables—that explain vaccine behavior (which was measured after the behavior had been carried out) also explain behavioral intent. We first report results from a multiple binary logistic model including only demographic variables, and follow that with models at each level of the SEM, controlling for demographics.

Demographic factors correlated with vaccine uptake—Demographic factors, including age, race/ethnicity, education, income, and gender were related to the dependent variable, having gotten the 2009 H1N1 vaccine (F (11, 1988) = 2.26; $p<0.01$). This model resulted in a McKelvey-Zavoina R^2 of 0.06. Older participants (OR = 1.02 for each year) were more likely to have gotten the vaccine adjusting for other demographics (income, education, age, gender, and race) ($p=0.001$). Other demographic characteristics were not related to having gotten the vaccine.

Minorities (Hispanics OR = 4.69; Blacks OR = 2.18) were more likely than Whites to *intend* to get the vaccine when a similar demographics-only model was used to examine behavioral intent. Those with high school education were less likely (OR = 0.46) to intend to get the vaccine than those with less than a high school education. Other demographic factors were not significantly related to intention to get vaccinated.

Intrapersonal level—We measured perceived risk from H1N1 using the 'Disease Risk Perception' scale (Table 3). For a majority of respondents, perceived risk of getting the disease, risk of complications from H1N1, and worry about getting very sick from H1N1 were only slightly or not at all important in their vaccine decision. We measured perceived risk from the vaccine using the 'Vaccine Risk Perception' scale. Between 19% and 28% reported agreement or strong agreement with statements about vaccines being unsafe or riskier than the disease (Table 3).

In multiple binary logistic regression with H1N1 vaccine uptake as the outcome, independent variables from the intrapersonal level—including attitudinal variables as well as past acceptance of the vaccine—controlling for demographic factors (F (18, 1799) = 8.19; $p<0.001$), resulted in a McKelvey-Zavoina R^2 of 0.53. The odds of vaccine uptake increased by 2.27 per unit increase on the 'Disease Risk Perception' scale. Those who perceived that getting the 2009 H1N1 vaccine is an effective way to prevent illness had 3.25 times the odds of others of having gotten the vaccine. Perceived risk from the vaccine predicted lower odds of vaccine uptake even after adjustment (OR=0.57), and perceived safety of the vaccine was related to increased odds of vaccine acceptance (OR=3.29). Trust in the government's handling of the pandemic was a significant predictor of acceptance of the vaccine only before adjustment. Subjective priority was related to greater odds of vaccine acceptance with p = 0.06 (OR=1.74). Those with a history of 'regular' acceptance of seasonal flu vaccine were 3.68 times more likely to have gotten the vaccine compared to those who 'seldom' received the seasonal flu vaccine. We did consider the possibility that past uptake of the seasonal flu vaccine and H1N1 vaccine uptake may be highly correlated and may be explained by common unobserved factors. In a bivariate probit model with past vaccine uptake and 2009 H1N1 vaccine uptake as the dependent variables and intrapersonal level variables as predictors, rho = 0.43; p<0.001, suggesting that the error terms in the equations predicting the two dependent variables are correlated. This variable may capture the impact of unobserved factors—such as propensity to accept vaccines—on H1N1 vaccine uptake. Furthermore, in published studies examining influenza vaccine uptake, past vaccination has been commonly used as a predictor. We therefore report results from a model including past vaccine uptake as a predictor of H1N1 vaccination. Removing this variable from the intrapersonal level model reduced the explained variance in vaccine uptake (McKelvey-Zavoina R^2) to 0.49.

Intent to get the vaccine was predicted by the same variables that predicted vaccine behavior: Disease Risk Perception, perceived effectiveness and safety of the vaccine, Vaccine Risk Perception, and getting the seasonal flu vaccine regularly predicted intention to get the vaccine (Table 4). Subjective priority did not predict vaccination intention after controlling for other variables within the intrapersonal level. Additionally, and similar to the analysis of vaccine behavior, trust in the government predicted intention to get the vaccine before, but not after, controlling for other intrapersonal variables. Since similar variables were found to predict vaccine uptake and intent to accept vaccine, we suspect that intrapersonal variables, and specifically attitudinal variables, determine vaccine acceptance and not vice versa (i.e., attitudinal variables are not formulated or reformulated after the acceptance of a vaccine).

Interpersonal level—The interpersonal level—the number of people influencing a positive vaccination decision and the number of people perceived to have gotten the vaccine—controlling for demographic factors (F (13, 1924) = 16.98; p<0.001), resulted in a McKelvey-Zavoina R^2 of 0.47. Considering that individuals are embedded in their social networks, we examined the additional variance explained by the interpersonal level when it is added to the intrapersonal level—this resulted in a McKelvey-Zavoina R^2 of 0.64.

Each additional person or group of people positively influencing vaccine acceptance was associated with 1.67 times greater odds of vaccine acceptance in multiple logistic regression (Table 4). Compared to respondents who reported 'very few' of their friends/family having gotten the vaccine, respondents who reported that 'most' got the vaccine had 8.31 times the odds of vaccine acceptance.

The analysis of intent to get the swine flu vaccine showed that each additional person positively influencing the vaccine decision was associated with 3.69 times greater odds of intending to get the vaccine—an odds ratio higher than that seen with the analysis of behavior. In contrast to behavior, however, respondents who reported that 'most' friends/family got the vaccine were not significantly more likely to intend to get the vaccine themselves compared to those who reported that 'very few' of their friends/family had gotten the vaccine.

Institutional level—The institutional level—including the amount of information about swine flu received from the healthcare provider and the belief that your doctor wants you to get the vaccine—controlling for demographic factors and presence of a healthcare provider (F (16, 1901) = 7.57; p<0.001) resulted in a McKelvey-Zavoina R^2 of 0.34. Adding the interpersonal level and intrapersonal levels increased the R^2 to 0.65. After controlling for having a regular healthcare provider, increasing amounts of information about swine flu received from the health care provider were related to increased odds of vaccine acceptance —those who received ‘a lot’ of information from their provider had 4.43 times the odds of having received the vaccine compared to those who received no information. Furthermore, belief that your doctor wants you to get the swine flu vaccine increased odds of vaccine uptake by 7.45 times.

Having received ‘a lot’ of information from the healthcare provider was also related to the intention to get the vaccine, and belief that your doctor wants you to get the swine flu vaccine resulted in 13.44 times higher odds of intending to get the vaccine (Table 4).

Community level—We measured perceived presence of disease at the community level with our 5-item ‘Community Risk’ scale. Between 12.3 and 20.1% of respondents reported that statements about the presence of illness, school closings, hospital overcrowding, and about swine flu being a serious problem in their community were mostly or completely accurate. 38.9% reported that people in their community were very worried about swine flu (Table 3).

Each unit increase on the ‘Community Risk’ scale resulted in 1.61 times greater odds of having gotten the vaccine (F (12, 1970) = 2.57; p=0.002) (Table 4). Controlling for demographic factors, the community level resulted in a McKelvey-Zavoina R^2 of 0.08, increasing to 0.65 on adding the other levels.

Each unit increase on this scale was also related to a 1.66 times greater odds of intending to get the vaccine, suggesting that presence of disease in the community impacted both vaccine behavior as well as intention to get the vaccine in the next month.

Policy level—The policy level—including access to health insurance and membership in a priority group for vaccination—controlling for demographic factors (F (13, 1966) = 2.45; p=0.003), resulted in a McKelvey-Zavoina R^2 of 0.08; this increased to 0.65 with all the other levels. Access to health insurance did not predict vaccine uptake in the overall sample. Objective priority, i.e. whether or not someone was in a priority group, measured objectively based on ACIP’s recommendations, was a significant predictor of vaccine uptake even after controlling for health insurance access and demographic factors (OR=1.68).

Given the timing of our survey, it is not surprising that objective priority group is not related to an intention to get the vaccine ‘in the next month’: when our survey was fielded, the CDC was urging everyone to get vaccinated.

Expecting that the number of uninsured is higher among minorities than among Whites, we examined the factors related to vaccine uptake in the policy level after stratifying the sample by race. The percentages of uninsured by race/ethnicity in our sample were: 16% among Whites, 21.5% among African Americans, and 40% among Hispanics (p<0.001), comparable to national estimates (Agency for Healthcare Quality and Research, 2008). Whereas having health insurance was not a significant predictor of vaccine uptake among Whites, African Americans with health insurance had 3.13 times the odds of African Americans without insurance of having gotten the vaccine (95% CI=1.11–8.79; p=0.03). The bivariate relationship between having insurance and vaccine uptake was significant among African Americans (Adjusted Wald F (1, 1910) = 6.86; p=0.008) but not among Whites (Adjusted Wald F (1,1915) = 1.15; p=0.284) or Hispanics (Adjusted Wald F

(1,1931) = 2.60; p=0.107). After adjustment for demographic variables and objective priority status, African Americans with insurance had 2.97 times the odds of those without insurance of having gotten the vaccine (95% CI=0.92–9.62; p=0.07) compared to an OR=1.03 (p=0.95) among Whites, and OR=1.39 (p=0.27) among Hispanics. The policy level model, after controlling for demographic factors, resulted in an R^2 of 0.26 for African Americans compared with 0.08 for Whites and 0.12 for Hispanics.

Overall Social Ecological Model—It is not our intention to interpret each predictor in the overall SEM due to possible multicollinearity/singularity problems. However, the overall model fit can be interpreted without any bias. 65% of the variance associated with H1N1 vaccine acceptance can be explained with all the levels of the social ecological framework and demographic variables (F (28, 1702) = 9.17; p<0.001).

Priority groups for vaccination

We measured membership in a priority group objectively (based on ACIP guidelines) and subjectively (respondents' perceived membership in a priority group to receive the vaccine first). Objective priority (at the policy level) and subjective priority (at the intrapersonal level) were each associated with vaccine uptake. To examine the interaction of these variables, we studied the distribution of subjective priority given objective priority status. As shown in Table 5, of 995 respondents who were not in an ACIP priority group, only seventy (7%) believed that they were. On the other hand, of 1058 respondents determined to be in an ACIP priority group based on objective measures, 730 (69%) did not believe they were in a priority group. Thus, the odds of underestimation of membership in a priority group were 10.43 times (95% CI = 8.15–13.52) that for overestimation (p<0.001). Vaccine uptake was highest among those who subjectively *and* objectively were in a priority group (35.6%; Table 5).

Conclusion

We believe that this is the first comprehensive study of factors related to influenza vaccine uptake and the first use of the SEM to examine this issue. We have shown that variables at all levels of the SEM impact having gotten the vaccine. The intrapersonal, interpersonal, and institutional levels have large effects on vaccine uptake, as evidenced by the proportion of variance explained by these levels individually. The community and policy levels explain a smaller proportion of the variance in vaccine uptake, but the proportion of variance explained by the policy level among African Americans is larger than among Whites or Hispanics. Table 6 presents the impact of each level on influenza vaccine uptake along with references of interventions designed to target the respective level.

The idea that individuals are embedded within social networks, which are in turn embedded within institutions and communities and impacted by policies is important and forms the theoretical basis for the SEM. We have shown, using self-reported survey data, that people's decision about getting the influenza vaccine is based not only on perceptions of their own individual risk, but also on the prevalence of vaccine uptake in their networks, their perceptions of disease risk in their communities, as well as on whether they are encouraged to get the vaccine by their healthcare providers and whether federal healthcare policies favor their access to the vaccine. A further test of the SEM's theoretical basis would involve data collected at various levels and from entire networks of individuals and is the direction our work points us in.

Furthermore, Burke et al. have pointed out that there may exist 'reciprocal determinism' between various levels of the SEM and the impacts on behavior may involve interactions between levels over time (Burke, Joseph, Pasick, & Barker, 2009). For example, the amount of information provided by a healthcare provider may have impacted vaccine-risk perception and hence vaccine uptake. We have not focused on interactions between levels in this study but that is an important future direction for research in this field. In the meantime, our findings should encourage public health practitioners to design interventions to simultaneously target multiple levels of the SEM in order to impact vaccine uptake.

While our study is the first to examine vaccine uptake through the lens of multiple SEM levels, multiple studies have studied the impacts of interventions at single levels. Among recent studies of interventions to increase vaccine uptake, multiple studies intervened at the intrapersonal (Bourgeois, Simons, Olson, Brownstein, & Mandl, 2008; Coady et al., 2008; Doratotaj, Macknin, & Worley, 2008; Kimura, Nguyen, Higa, Hurwitz, & Vugia, 2007; Nowalk et al., 2010; Panda, Stiller, & Panda, 2010) and institutional levels (Chapman, Li, Colby, & Yoon, 2010; Lin et al., 2010; Minor et al., 2010; Nace, Hoffman, Resnick, & Handler, 2007; Nowalk et al., 2010; Nowalk et al., 2008; Weaver et al., 2007). Relatively fewer studies targeted interpersonal (Coady et al., 2008; Nace et al., 2007) and policy levels (Coady et al., 2008; Kimura et al., 2007), and we could not find any studies that aimed to increase uptake by targeting perceived risk at the community level.

Health education interventions (aimed at the intrapersonal level) that also targeted another level of the SEM (Coady et al., 2008; Kimura et al., 2007; Lin et al., 2010; Nowalk et al., 2008) were more effective than those targeting only the intrapersonal level (Bourgeois et al., 2008; Doratotaj et al., 2008). Similarly, in a systematic review of interventions to increase uptake among health care personnel, Lam et al. report that interventions that used role models or improved access to vaccines in addition to health education were more effective than health education alone (Lam, Chambers, MacDougall, & McCarthy, 2010). Kimura et al. showed that whereas health education on its own was not effective in increasing vaccine uptake, it was when combined with the provision of free vaccines at a well-publicized “vaccine day” (Kimura et al., 2007). Nace et al. implemented an intervention employing not only posters and videos to educate health care workers about the importance of influenza vaccination, but also promotion of the vaccine by the leadership in the organization (Nace et al., 2007), pointing to the importance of the social network, role models, and the interpersonal level. Thus, though the intrapersonal level explained a larger proportion of the variance in vaccine uptake compared to other levels in our study, interventions targeting this level have been found to be most effective in conjunction with the interpersonal, institutional, or policy levels. Beliefs and attitudes, which are the target of most interventions at the intrapersonal level, may be more amenable to change when targeted by a known person from the social network—friends, family, colleagues, role models—rather than using passive education materials. Our study supports this possibility by showing that larger proportions of the total variance in vaccine uptake can be explained by the intrapersonal level in conjunction with the interpersonal level.

Increased or simplified access to vaccines appears also to improve the effectiveness of interventions targeting the intrapersonal level (Kimura et al., 2007; Lam et al., 2010). We categorize this as a policy-level variable. The small proportion of the variance explained by the policy level is most likely due to free provision of the vaccine by the federal government which facilitated access to the H1N1 vaccine in the overall sample. Although federal funding covered the costs of the H1N1 vaccine itself as well as of administration at public health departments, mass vaccination clinics and through commercial community vaccinators effectively removing the need for insurance (Centers for Disease Control and Prevention, 2009), African Americans without insurance were less likely to have gotten the vaccine than those with insurance. Perhaps uninsured African Americans were not as aware as those with insurance that the H1N1 vaccine was available free of cost. It is possible that communication to this subgroup failed to address the lack of health insurance as a perceived barrier to influenza vaccine uptake. Thus, once again, our study points to the importance of effective interventions at multiple levels: communication targeting the intrapersonal level as well as improved access to vaccines through policy. In the future, communication to African Americans should clearly indicate whether insurance is needed to cover the costs of vaccination, and where those without insurance can go to get the vaccine. In September 2010, some provisions of the Affordable Care Act went into effect, including free provisions of influenza vaccinations (U.S. Department of Health & Human Services, 2010). This provision is not only important to help ensure that African Americans and others without insurance can receive influenza vaccinations but it is equally important that this access is widely communicated to the public.

Vlahov et al. have suggested that interventions aimed at multiple levels are especially important when targeting hard-to-reach populations including minorities (Vlahov, Coady, Ompad, & Galea, 2007). Coady et al. found that education materials such as posters, flyers, etc., interpersonal dialog between implementers of the intervention and community members during community meetings, and the provision of vaccine in clinics and door-to-door campaigns resulted in an increase in interest in getting the influenza vaccine even among hard-to-reach populations (Coady et al., 2008). Nowalk et al. found that they could increase influenza vaccine uptake in all race/ethnicities at an inner city clinic through interventions that included patient reminders, standing orders for vaccination, and increasing access to the vaccine through community-based clinics and free flu shots (Nowalk et al., 2008). Similarly, our results point out the importance of real and perceived access to vaccine as a determinant of uptake by minorities, especially African Americans. The policy level appears, therefore, to be especially important in removing racial *disparities* in influenza vaccine uptake.

Another policy-level variable—objective priority—was a predictor of having gotten the vaccine. However, people greatly underestimated their membership in a priority group. This same effect was also reported during the 2004 influenza vaccine shortage (Brewer & Hallman, 2006), and was alleviated by provider-issued vaccination recommendation during the pandemic (Maurer, Uscher-Pines, & Harris, 2010a). We have shown here that this underestimation has an effect on vaccine uptake: only 15% of those who underestimated their presence in a priority group were vaccinated compared to 35% of those who realized that they were in a priority group. This will be even more important in the future since in 2010, the ACIP instituted a universal recommendation for the flu vaccine for all over 6 months of age (Fiore et al., 2010). The low awareness of priority group status found in this study suggests the need for extensive communication efforts aimed at groups such as young and middle aged adults, who were not targeted for seasonal influenza vaccination in the past. It also places significant responsibility on healthcare providers, who must take an aggressive stance in communicating the need for the vaccine to their patients. Therefore, the CDC and groups such as the American Medical Association should produce materials to support physicians in playing this critical role in communication.

The amount of information received from a health care provider about swine flu predicted vaccine uptake. There may be a blurring of the distinction between the interpersonal and institutional levels in the case of people who have a close relationship with their regular healthcare provider. However, in the US, where care is provided through large physician practices and interactions with physicians are typically of short duration, we believe we are justified in categorizing the amount of information received from the healthcare provider as an institutional level variable (Yarnall, Pollak, Ostbye, Krause, & Michener, 2003). There may be other channels for receiving information about the disease, each of which may have an influence on behavior (Maurer et al., 2010c). Furthermore, there may be interactions between the institutional and intrapersonal levels: Cummings *et al.* showed that exposure to 'pro-swine flu shot information' impacted perceived efficacy of vaccination (Cummings et al., 1979). Such interactions are an avenue for future research.

We have shown that the interpersonal level is extremely important, explaining 47% of the variance in vaccine behavior. In addition, the odds of intending to get the vaccine were even higher than the odds of having gotten the vaccine for those with a larger 'size of influential network' of family and friends who want them to get the vaccine. People who intend to get the vaccine may have had the opportunity to discuss vaccine behavior with more people in their network than those who already got the vaccine had a chance to do. Whether most friends and family got the vaccine appears to impact vaccine behavior but not behavioral intent. We hypothesize that people may have gone with their family to get the vaccine during the second wave of the pandemic. However, those who intended to get the vaccine after January may be part of a social network that weighed the pros and cons of the decision, with fewer friends/family having already gotten the vaccine. Our results showing the importance of social networks both in directly influencing individuals and in establishing social norms should be incorporated into messages to convince individuals to get vaccinated. For example, we suggest that older adults, over 65, who have a strong history of prior vaccination, may be important messengers and role models in reaching out to younger members of their familial and social networks. One example of this type of message is being utilized in 2011 in the state of Maryland: in public service announcements, grandparents advocate for influenza immunization for their grandchildren by talking directly to their adult son/daughter.

In agreement with other studies (Maurer et al., 2010b; SteelFisher, Blendon, Bekheit, & Lubell, 2010), we find that intrapersonal variables such as risk perception from the disease and the vaccine are related to vaccine uptake—both having gotten the vaccine and intention to get it. In addition, past vaccine uptake is strongly correlated with 2009 H1N1 vaccine uptake. It is possible that these two behaviors are endogenous, however, and we caution readers about the interpretation of this finding in our and previous studies (Eastwood et al., 2010; Maurer et al., 2009; Schwarzinger et al., 2010; Seale et al., 2010). There may be unobserved factors that impacted 2009 H1N1 vaccine uptake via past vaccination behavior.

A common critique of cross-sectional studies of vaccine uptake is that attitudinal variables (such as belief in vaccine safety) found to be correlated with behavior could well be a result of the behavior rather than the other way around. We have provided evidence that similar attitudinal variables also impact *intention to get the vaccine*. This suggests that these attitudes are indeed determinants of vaccine uptake. Overall, our estimate of vaccine uptake is similar to that estimated by the CDC (Centers for Disease Control and Prevention, 2010c), providing confidence that our sample accurately represents the US population.

Disease prevalence and perceived risk in the community impact behavior. Our 'Community Risk' scale shows that we can measure perceived prevalence and risk of disease in the community and that this social context impacts vaccine uptake. Another community-level belief that may impact vaccine uptake is the number of people in the community that the respondent perceives has received the vaccine. This has implications for perceived herd immunity in the community, and should be examined in the future. Furthermore, availability of vaccine in the community—which we would define as a policy variable and which we are unable to estimate—may also determine vaccination rates (Centers for Disease Control and Prevention, 2010d; Molly Hennessy-Fiske, 2010). Minorities were more likely than Whites to intend to get the vaccine 'in the next month.' This may be because more minorities took their time to arrive at a decision regarding getting the vaccine; on the other hand, minority communities may have found it more difficult than Whites to access the vaccine until after the vaccine shortage had passed.

In sum, we have shown that attitudinal factors and past behavior at the intrapersonal level, the beliefs and actions of others in the social environment at the interpersonal level, information from a regular health care provider at the institutional level, presence of disease and risk at the community level, and access to health care and membership in a priority group at the policy level, all impact vaccine uptake. This work has clear implications for the design of targeted communication through interpersonal channels to impact vaccine uptake among at-risk people. The study also suggests that policy-level changes including increasing access to health insurance as a result of health reforms in the US could influence vaccine uptake in the future.

Importantly, this study validates the levels of the SEM as determinants of vaccine uptake behavior. Additionally, the finding that each level explains a proportion of the variance associated with the vaccine decision and all levels together explain more than any individual level effectively expands the possible range of interventions to increase vaccination and implores health practitioners to design interventions targeting multiple levels of the social ecological framework in order to get the greatest increases in influenza vaccine uptake. Future research could explicitly initiate formal tests of the SEM with data collected at multiple levels of the framework in order to further inform interventions aimed at influenza vaccine uptake.

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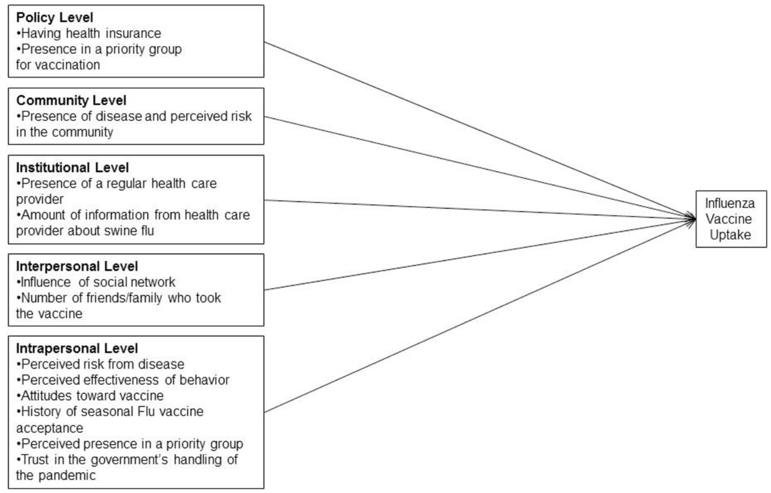

Figure 1.
A Social Ecological Framework for 2009 H1N1 Influenza Vaccine Uptake in the US

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Table 1

Distribution of vaccine decision in sample

Vaccine Decision	Unweighted N	Weighted %
Behavior (N=2059[a])		
Got the vaccine	403	18.4
Did not get the vaccine	1656	81.6
Behavioral Intent (N=1656)		
Intend to get the vaccine in the next month	151	8.6
Do not intend to get the vaccine	1109	73.3
Don’t Know[b]	396	18.1

[a] 20 cases with missing outcome variable were discarded for this study.

[b] The ‘Don’t Know’ response is conceptually distinct from ‘Yes’ or ‘No,’ and was left out of the analyses of behavioral intent in the rest of this study

Table 2

Demographic characteristics of respondents

	Overall		Behavior; N=2059 Got 2009 H1N1 Vaccine[a]		Behavioral Intent; N=1260 Intend to get 2009 H1N1 Vaccine[b]	
Characteristic	**N[c]**	**%[d]**	**N[c]**	**%[d]**	**N[c]**	**%[d]**
Total	2059[e]	100	403	18.4	151	10.5[f]
Income						
Under 25K	547	25.3	110	14.7	51	10.3
25K – 50K	580	25.4	101	17.1	49	11.9
50K – 75K	394	22.3	78	22.2	25	9.7
≥75K	538	27.0	114	19.8	26	10.2
Education						
<High School	307	13.9	75	20.9	35	18.8
High School	669	31.1	100	14.6	57	8.1
Some College	587	28.4	120	16.6	31	9.8
≥Bachelor's degree	496	26.5	108	23.4	28	10.4
Gender						
Male	974	49.1	191	19.8	64	9.6
Female	1085	50.8	212	17.0	87	11.4
Age, years[g]						
Mean (SD)	46.9 (0.6)		50.6 (1.4)		47.4 (2.2)	
Race/Ethnicity						
White, NH[h]	844	69.3	163	18.5	39	7.3 †
Black, NH[h]	585	11.5	105	18.2	37	13.8
Hispanic	594	14.3	128	19.6	72	26.4
Other, NH[h]	36	4.9	7	12.8	3	14.0
Health Insurance						
Yes	1560	78.1	331	19.8*	102	10.2
No	479	21.9	62	12.5	48	11.8

	Overall		Behavior; N=2059 Got 2009 H1N1 Vaccine[a]		Behavioral Intent; N=1260 Intend to get 2009 H1N1 Vaccine[b]	
Characteristic	**N[c]**	**%[d]**	**N[c]**	**%[d]**	**N[c]**	**%[d]**
Regular Health Care Provider						
Yes	1637	77.2	350	20.5**	119	10.4
No	407	22.8	48	10.2	32	11.0

[a]Behavior is measured as self-report of having gotten the swine flu vaccine (Yes/No);

[b]Behavioral intent is measured as intent to get the vaccine in the next month (Yes/No/Don't Know). 396 cases that responded 'Don't know' are not included in the analyses here.

[c]Unweighted N;

[d]Weighted %;

[e]20 cases with missing outcome variable were discarded for this study;

[f]Note that those who responded "Don't know" were left out of the analysis of behavioral intent, leading to a denominator of 1260 rather than the 1656 in Table 1.

[g]Age is a continuous variable and mean age is reported.

[h]Non-Hispanic;

Adjusted Wald chi-square test p-values

[†]p<0.001;

[**]p<0.01;

[*]p<0.05

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Table 3

Scales to measure risk at the intrapersonal level (Disease Risk Perception and Vaccine Risk Perception), and the community level (Community Risk).

Survey Question	**N[a]**	**%[b]**
Intrapersonal Level		
Disease Risk Perception scale; α=0.83	1989[c]	
How important is each of the following reasons in your decision about the swine flu vaccine?		
I am at risk of getting swine flu	2012	
Not important at all	935	47.90
Slightly important	493	26.56
Moderately Important	345	17.48
Very important	239	08.06
I am at risk of complications from the swine flu	2005	
Not important at all	942	48.00
Slightly important	476	26.00
Moderately Important	314	14.05
Very important	273	11.94
I'm worried about getting very sick from swine flu	2019	
Not important at all	589	34.00
Slightly important	487	25.82
Moderately Important	385	18.82
Very important	558	21.35
Vaccine Risk Perception scale; α =0.79	1972[c]	
Indicate whether you agree or disagree with each of the following statements		
A vaccine is riskier/more dangerous than the disease itself	2004	
Strongly disagree	420	21.14
Disagree	982	51.63
Agree	489	22.06
Strongly agree	113	05.17
Most vaccines are not safe	2008	
Strongly disagree	426	21.96
Disagree	1150	58.77
Agree	348	15.51
Strongly agree	84	03.77
Children are at greater risk from vaccines than from diseases	1995	
Strongly disagree	390	21.29
Disagree	1031	50.32
Agree	462	24.01
Strongly agree	112	04.39
Community Level		
Community Risk scale; α=0.79	2042[d]	

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Survey Question	**N**[a]	**%**[b]
How accurate is each of the following statements in describing swine flu in your community?		
There are lots of people in my community who have or have had swine flu	2039	
Completely Inaccurate	745	32.98
Mostly Inaccurate	923	47.08
Mostly accurate	331	18.62
Completely accurate	40	01.32
Schools have been closed in my community as a result of swine flu	2044	
Completely Inaccurate	1,241	58.55
Mostly Inaccurate	470	24.41
Mostly accurate	227	11.64
Completely accurate	106	05.40
Hospitals in my community have been overcrowded because of swine flu	2039	
Completely Inaccurate	1026	49.03
Mostly Inaccurate	754	38.76
Mostly accurate	198	09.89
Completely accurate	61	02.32
People in my community are very worried about swine flu	2037	
Completely Inaccurate	433	18.02
Mostly Inaccurate	831	43.55
Mostly accurate	646	33.50
Completely accurate	127	04.93
Swine flu is a serious problem in my community	2036	
Completely Inaccurate	806	40.29
Mostly Inaccurate	915	46.99
Mostly accurate	252	10.58
Completely accurate	63	02.15
Scales	Mean	SD
Disease Risk Perception scale (Range 1–4)	2.12	0.95
Vaccine Risk Perception scale (Range 1–4)	2.11	0.66
Community Risk scale (Range 1–4)	1.82	0.60

[a]Unweighted N;

[b]Weighted %;

[c]Number of cases with no missing values;

[d]Number of cases with <2 missing values

Table 4

Impact of characteristics at each level of the Social Ecological Model on Vaccine uptake

	Got Vaccine[a]; N=2059		**Intend to get vaccine[b]; N=1260**	
Characteristic	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)[c]**	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)[c]**
Intrapersonal Level	N=1877	N=1877[d]; R^2=0.53	N=1155	N=1155
Disease Risk Perception	2.51 (2.06–3.05)[†]	2.27 (1.81–2.84)[†]	2.85 (1.99–4.09)[†]	3.72 (2.28–6.07)[†]
Getting the 2009 swine flu vaccine is effective (ref: Not effective)	8.07 (5.01–13.02)[†]	3.25 (1.90–5.56)[†]	12.31 (6.26–24.17)[†]	6.91 (3.08–15.50)[†]
Vaccine Risk Perception	0.31 (0.22–0.44)[†]	0.57 (0.39–0.84)[**]	0.42 (0.23–0.78)[**]	0.50 (0.27–0.92)[*]
Agree that newly developed vaccine is safe (ref: Disagree)	7.29 (2.81–18.89)[†]	3.29 (1.33–8.11)[*]	22.77 (10.46–49.55)[†]	20.25 (6.47–63.40)[†]
Trust in government	1.97 (1.50–2.57)[†]	1.04 (0.73–1.49)	2.30 (1.34–3.92)[**]	1.40 (0.76–2.60)
Get seasonal flu vaccine regularly (ref: seldom)	6.61 (4.33–10.08)[†]	3.68 (2.12–6.39)[†]	3.97 (1.86–8.46)[†]	2.64 (1.13–6.18)[*]
Subjective Priority	2.83 (1.83–4.36)[†]	1.74 (0.97–3.15)	3.17 (1.46–6.89)[**]	1.93 (0.69–5.42)
Interpersonal Level	N=1997	N=1997[d]; R^2=0.47	N=1228	N=1228
Size of influential network	1.87 (1.69–2.06)[†]	1.67 (1.51–1.86)[†]	3.11 (2.64–3.66)[†]	3.69 (2.81–4.85)[†]
Most friends/family got the vaccine (ref: very few)	13.12 (7.73–22.28)[†]	8.31 (4.75–14.55)[†]	2.05 (1.03–4.06)[*]	0.56 (0.23–1.36)
Institutional Level	N=1977	N=1977[d]; R^2=0.34	N=1218	N=1218
Have a regular health care provider	2.34 (1.12–4.89)[*]	1.06 (0.42–2.69)	0.99 (0.38–2.55)	0.49 (0.12–1.98)
Information from health care Provider (ref: None at all)				
A little	2.40 (1.21–4.74)[*]	1.97 (0.83–4.69)	1.43 (0.42–4.92)	0.92 (0.29–2.85)
Some	4.20 (2.34–7.55)[†]	2.72 (1.40–5.27)[**]	2.20 (0.76–6.38)	1.34 (0.51–3.56)
A lot	6.50 (3.45–12.23)[†]	4.43 (2.23–8.78)[†]	4.39 (1.52–12.64)[**]	2.80 (1.22–6.44)[*]
Doctor wants you to get swine flu vaccine	8.38 (4.94–14.23)[†]	7.45 (4.63–12.01)[†]	11.52 (4.13–30.65)[†]	13.44 (7.11–25.42)[†]
Community Level	N=2042	N=2042[d]; R^2=0.08	N=1252	N=1252
Community Risk	1.60 (1.19–2.16)[**]	1.61 (1.19–2.18)[**]	1.64 (1.09–2.47)[*]	1.66 (1.09–2.54)[**]
Policy Level	N=2039	N=2039[d]; R^2=0.08	N=1255	N=1255

	Got Vaccine[a]; N=2059		Intend to get vaccine[b]; N=1260	
Characteristic	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)[c]**	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)[c]**
Have health insurance	1.72 (0.92–3.24)	1.28 (0.63–2.63)	0.85 (0.45–1.59)	0.93 (0.53–1.63)
Objective Priority	1.49 (0.98–2.27)	1.68 (1.09–2.59)*	1.17 (0.59–2.33)	1.26 (0.63–2.53)

*Adjusted Wald chi-square or t-test p value≤0.05;

**p<0.01;

†p<0.001;

[a]Comparison to those who did not get the vaccine;

[b]Comparison to those who do not intend to get the vaccine in the next month. Large Odds Ratios in this analysis reflect the small number of people who intend to get the vaccine and should be interpreted with caution; we do not report R2 for these models due to the large Odds Ratios. However, we present this analysis as a comparison of the determinants of *behavior* and *behavioral intent*, important to accurately identify determinants of vaccine uptake in a cross-sectional framework;

[c]Adjusted for demographics and other variables in the same level of the SEM;

[d]N varies between adjusted models based on missing data. Unadjusted models were constrained to include only cases also included in the adjusted model for the same level of the social ecological framework; we used listwise deletion for each multiple logistic regression model.

Table 5

Underestimation of membership in a priority group by respondents. Vaccine uptake in each group, based on objective and subjective membership in a priority group, is shown.

		Objective Priority				
		No		Yes		p-value[c]
		N[a]	% Got 2009 H1N1 Vaccine[b]	N[a]	% Got 2009 H1N1 Vaccine[b]	
Subjective	No	925	14.9	730	15.2	<0.001
Priority	Yes	70	21.9	328	35.6	

[a]Unweighted N;

[b]Weighted %;

[c]McNemar's non-parametric chi-square test

Table 6

Variance in vaccine uptake decision explained by levels of the Social Ecological Framework; N=1790. Also shown are interventions designed to target the levels.

	R^2 (this study)	Interventions
Policy	0.08	Access to vaccine: Free vaccines and door-to-door vaccination[1,3]
Policy + Community + Institutional + Interpersonal + Intrapersonal	0.65	
Community	0.08	
Community + Institutional + Interpersonal + Intrapersonal	0.65	
Institutional	0.34	Opt-out policy[2,12]; Reminders[2,6,10,11]; Choice of intranasal and injection vaccines[5,8]; Standing orders for vaccination[10]
Institutional + Interpersonal + Intrapersonal	0.65	
Interpersonal	0.47	In-person education[2]; Information provided at community meetings[3]
Interpersonal + Intrapersonal	0.64	
Intrapersonal	0.53	Posters, videos etc. for health education[1,3,7,9] Mailed education letters[4] Advertizing vaccine clinics[5,8]

[1](Kimura et al., 2007);

[2](Nace et al., 2007);

[3](Coady et al., 2008);

[4](Doratotaj et al., 2008);

[5](Nowalk et al., 2010);

[6](Weaver et al., 2007);

[7](Panda et al., 2010);

[8](Lin et al., 2010);

[9](Bourgeois et al., 2008);

[10](Nowalk et al., 2008);

[11](Minor et al., 2010);

[12](Chapman et al., 2010)