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Inspecting the Mechanism: A Longitudinal Analysis of Socioeconomic Status Differences in Perceived Influenza Risks, Vaccination Intentions and Vaccination Behaviors during the 2009-2010 Influenza Pandemic

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Abstract

Background—Influenza vaccination is strongly associated with socioeconomic status, but there is only limited evidence on the respective roles of socioeconomic differences in vaccination intentions vs. corresponding differences in follow through on initial vaccination plans for subsequent socioeconomic differences in vaccine uptake.

Methods—Nonparametric mean smoothing, linear regression and Probit models were used to analyze longitudinal survey data on perceived influenza risks, behavioral vaccination intentions and vaccination behavior of adults during the 2009-10 influenza A/H1N1 ("Swine Flu") pandemic in the United States. Perceived influenza risks and behavioral vaccination intentions were elicited prior to the availability of H1N1 vaccine using a probability scale question format. H1N1 vaccine uptake was assessed at the end of the pandemic.

Results—Education, income and health insurance coverage displayed positive associations with behavioral intentions to get vaccinated for pandemic influenza while employment was negatively associated with stated H1N1 vaccination intentions. Education and health insurance coverage also displayed significant positive associations with pandemic vaccine uptake. Moreover, behavioral vaccination intentions showed a strong and statistically significant positive partial association with later H1N1 vaccination. Incorporating vaccination intentions in a statistical model for H1N1 vaccine uptake further highlighted higher levels of follow through on initial vaccination plans among persons with higher education levels and health insurance.

Limitations—Sampling bias, misreporting in self-reported data, and limited generalizability to non-pandemic influenza are potential limitations of the analysis.

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Conclusions—Closing the socioeconomic gap in influenza vaccination requires multi-pronged strategies that not only increase vaccination intentions by improving knowledge, attitudes and beliefs but also facilitate follow through on initial vaccination plans by improving behavioral control and access to vaccination for individuals with low education, employed persons and the uninsured.

Keywords

Influenza Vaccination; Influenza Pandemic; Socioeconomic Disparities; Medical Decision Making; Behavioral Economics; Behavioral Intentions; Vaccination Behavior

Introduction

Compared to persons with low socioeconomic status (SES), persons with high SES have better health and longevity.[1-11] SES differences in health behaviors are important determinants of the SES gradient in health and mortality. Such SES differences have been documented for many health behaviors including smoking, eating, exercising, preventive healthcare use, and treatment adherence as well as different markers of SES.[2,5-7,12-19] Differences in health behaviors across education groups are thereby especially common.[5-7,13-16] Understanding the causes of these SES differences in health behaviors is critical for the development of effective strategies to reduce SES-related disparities in health and mortality.[2,20,21]

Like many other health behaviors, adult influenza vaccination also displays strong SES gradients, especially by education.[22-29] These SES gradients in influenza vaccination are particularly troubling, as lower SES groups are more commonly affected by chronic risk factors for influenza-related complications and death, such as diabetes, heart or lung disease.[1,3,5,9,10,30,31] Alleviating disparities in influenza vaccination is thus a key public health priority of Healthy People 2020.[21]

Standard economic models of health behaviors typically assume that health investments solely depend on individuals' preferences and constraints.[32-35] Decision makers compare the expected benefits and cost of different choices in terms of their overall discounted utilities and then pick the alternative that yields the highest level of utility. In the case of influenza vaccination, decision makers compare the expected discounted benefits of vaccination such as the perceived reduction in future infection and mortality risk with the expected discounted cost of vaccination such as the perceived risk of side effects or the financial and time cost of vaccination.[25] Within this framework, individuals get vaccinated if their expected net present value of the utility of vaccination is positive, i.e., if their expected discounted benefits of vaccination outweigh their expected discounted costs. In these models, observed behaviors directly reveal whether or not decision makers' expected discounted net utilities of vaccination were higher or lower than their expected discounted net utility of remaining unvaccinated given their constraints.

Recent research in behavioral economics and psychology, however, indicates that the standard economic approach to decision-making may be too simplistic for modeling health behaviors, including influenza vaccination decisions.[36-39] Individuals often have difficulties

in acting according to their own stated preferences due to, say, limited self-control or procrastination, which commonly prevent behavioral change.[40] These behavioral economics models are similar to models from health psychology, which distinguish between behavioral intentions and resulting behaviors, often highlighting the important role of self-control for moving from behavioral intentions to action.[41-44] For example, a smoker may well report a preference for not smoking, but find it challenging to quit. As a result, individuals' subjective utility of certain health behaviors may be higher than that of their observed actions, which challenges a purely deductive approach to inferring utility from observed behaviors alone. Similarly, time-inconsistent preferences may lead to procrastination and a resultant divergence of current plans (as measured by self-reported behavioral intentions) from later actions. Using longitudinal data to jointly study behavioral intentions and subsequent behaviors thus offers the potential to distinguish differences in preferences for certain health behaviors from issues of behavioral control and other (unexpected) barriers to implement initial plans for action.

This paper explores the relative importance of SES differences in vaccination intentions vs. corresponding differences in follow through on initial vaccination plans for subsequent SES differences in influenza vaccine uptake of adults during the 2009-2010 influenza pandemic in the United States. I analyzed longitudinal data from a national sample of U.S. adults, which contain real-time probability scale measures of behavioral intentions to get vaccinated just prior to the availability of pandemic influenza vaccine in the Fall of 2009 as well as measures of later vaccine uptake during the 2009-2010 pandemic. Motivated by the aforementioned behavioral models of decision-making in health[41-44], I contrast behavioral vaccination intentions with subsequent vaccination outcomes across different SES groups. Analyzing SES differences in both vaccination intentions and behaviors helps distinguish SES-related differences in individuals' willingness to get vaccinated as summarized by their stated behavioral intentions from SES-related differences in follow through on initial vaccination plans, which point toward potential issues of behavioral control or unanticipated access barriers to influenza vaccine. Along the way, I also explored SES differences in perceived influenza risks as a potential driver of SES differences in vaccination intentions and behavior.

Based on existing evidence for positive SES gradients in influenza vaccination[23-29] and positive relationships between perceived influenza risks and influenza vaccine uptake[45], I expected positive associations between SES and perceived influenza risks. Similarly, I anticipated higher behavioral vaccination intentions among higher SES persons given the aforementioned evidence on the predictive power of behavioral intentions for subsequent health behaviors. In line with the previous literature, I further hypothesized a positive relationship between SES and vaccine uptake. I also suspected this positive association to persist, once behavioral intentions are included in the model for vaccine uptake, as low SES persons may have lower levels of behavioral control and face larger (unforeseen) challenges in accessing healthcare, which could limit their follow through on initial vaccination plans.

Background: Influenza, pandemic influenza and influenza vaccination

Influenza is a common, but potentially dangerous, respiratory disease caused by influenza viruses. During the period 1976-2007, influenza caused between 3,000 and 50,000 deaths per year in the United States alone.[46,47] Occasionally, influenza viruses spread over a wide geographic area and affect a large proportion of the population, giving rise to a so-called influenza pandemic.[48] In 2009-2010, the world experienced the first influenza pandemic in over 40 years. In the spring of 2009, influenza A/H1N1 virus first affected humans in Mexico, before spreading rapidly to the United States and other countries around the world. On June 11, 2009, the WHO declared the H1N1 outbreak a phase 6 pandemic, which lasted until August 10, 2010. In the United States, the 2009 influenza pandemic led to roughly 43 to 89 million influenza cases, 195,000 to 403,000 hospitalizations and 8,870 to 18,300 deaths.[49] Its overall morbidity and mortality impact was thus comparable to that of previous non-pandemic influenza seasons. However, the pandemic H1N1 virus more commonly affected younger persons compared to previous influenza seasons which had the highest disease burden among older adults.[50] Persons with certain medical conditions such as diabetes, chronic heart or lung disease were generally at increased risk of influenza-related complications and death during both non-pandemic influenza seasons and pandemics.[46,51]

Vaccination is the primary tool for preventing influenza infection and disease burden including influenza-related morbidity, work absenteeism, healthcare utilization and mortality.[46] Despite considerable evidence regarding its effectiveness and safety [46,52,53], influenza vaccination levels remain below national targets such as Healthy People 2020[21,54] and are especially low among lower SES groups.[23-29]

Increased risks of influenza among lower SES groups due to higher rates of chronic diseases and relatively low vaccination levels result in sizable SES disparities in levels of protection against influenza and influenza-related complications. To be able to address these disparities, it is important to better understand the behavioral mechanisms and potential barriers that lead to less vaccination among lower SES groups. The lower vaccination levels among low SES adults may have many potential causes including lower preferences for influenza vaccination due to, say, lower perceived risks of influenza, insufficient knowledge of or less favorable attitudes toward vaccination, reduced access to influenza vaccine or lower levels of behavioral self-control in these population strata. Understanding the relative importance of these potential causes helps to design policies and interventions to alleviate SES gradients in influenza vaccination, as their respective impact will likely depend on what causes these SES gradients in the first place. For example, information campaigns may be well suited to address low levels of knowledge of and unfavorable attitudes toward vaccination. Improved supply infrastructures for influenza vaccination, such as worksite vaccination programs, retail clinics or routine offering of influenza vaccine during healthcare visits, in turn, may be better suited to address barriers to vaccine access or low self-control in following through on existing vaccination plans by making vaccination more accessible and convenient.

Data, Measures and Methods

I analyzed unique longitudinal data from multiple waves of the RAND American Life Panel (ALP). The ALP is a nationally representative Internet panel of U.S. adults aged 18 and over, which has been operated by the RAND Corporation since 2006. At the time of the initial data collection for this analysis (August 2009), the ALP included 2,694 panelists, most of whom had been recruited from the sample of the nationally representative Survey of Consumer Attitudes of the University of Michigan. The ALP reached out to both online and offline households: If a prospective panelist did not have Internet access at the time of recruitment, she received a WebTV device or laptop computer in exchange for her participation in the panel. ALP participants also received small duration-dependent financial compensations of roughly 10 USD per 15 minutes of interview time. The ALP conducted surveys of about 30 minutes or less at least twice a month. The data from this study and further details about the ALP are publicly available at https://mmicdata.rand.org/alp/index.php?page=main.

During the 2009-2010 H1N1 pandemic and its immediate aftermath, the ALP fielded 12 surveys concerning H1N1 influenza, influenza vaccination and related issues such as perceived influenza risks, behavioral vaccination intentions and vaccine uptake.[55,56] The survey also collected information on health-risk factors for H1N1-related complications as summarized in the government's H1N1 vaccination recommendations.[51] I used data from three of the 12 ALP influenza surveys, which were conducted between 17 and 31 August 2009 (“wave 7”), 19 November and 10 December 2009 (“wave 9”) and 17 May and 25 June 2010 (“wave 11”), respectively. These three survey waves contain the key measures of vaccination intentions just prior to the availability of H1N1 vaccine (“wave 7”) and vaccination status at the end of the pandemic (“wave 11”) as well as other important explanatory variables such as H1N1-specific health risk factor during the pandemic (“wave 9”), which are especially pertinent to the analysis.

Behavioral vaccination intentions immediately prior to H1N1 vaccine availability in the Fall of 2009 were assessed during wave 7 using a probability scale question format. Following an introduction about probabilities, which are commonly employed in the ALP[57], respondents were asked: “If a vaccine becomes available for the H1N1 (swine) flu this fall, what are the chances that you would get the vaccine?” Permissible answers ranged from 0 to 100 percent. This probability scale question format for measuring behavioral intentions has the advantage that responses can incorporate uncertainty regarding future actions at the time of the interview rather than forcing respondents to express their plans within a less nuanced binary yes-no-format.[55,58] This probability scale question on H1N1 vaccination intentions was supplemented by two questions concerning respondents' perceived H1N1 risks. The first question elicited respondents' perceived short-term risks of infection based on the item “What do you think are the chances that you will get H1N1 (swine) flu in the next month?”, while the second question assessed their perceptions of the mortality threat of a potential H1N1 infection based on the question “If you do catch H1N1 (swine) flu, what do you think are the chances that you will die from it?” Permissible answers to both risk questions ranged from 0 to 100 percent. Previous research based on multiple ALP waves showed that mean perceived infection risks over time closely tracked the temporal pattern of H1N1 virus

activity as measured by weekly CDC data on outpatient visits for influenza-like illnesses and hospitalizations.[56]

Measures of behavioral intentions for H1N1 vaccination and H1N1 risk perceptions were complemented by detailed information on health-risk factors for H1N1-related complications used by the CDC's Advisory Committee on Immunization Practices to define the government's adult vaccination recommendations for H1N1.[51] CDC initially prioritized H1N1 vaccination for persons aged 18 to 24, persons aged 24 to 64 with specific chronic health problems (diabetes, heart disease, chronic lung disease, asthma, neurologic or neuromuscular disease, immune system problems, kidney disease, sickle cell disease or hemophilia), pregnant women, and persons involved in formal or informal care for persons at elevated H1N1 risk. Corresponding respondent characteristics were collected in ALP wave 9. Information on these characteristics was aggregated into a binary variable indicating respondents' coverage by a government H1N1 vaccination recommendation. H1N1 vaccination status at the end of the pandemic was measured during wave 11 based on the yes-no-question: “There are two types of H1N1 (swine) flu vaccinations. One is a shot and the other is a spray, mist or drop in the nose. Have you had an H1N1 (swine) flu vaccination?”

I also used sociodemographic data on respondents' age, sex, race and ethnicity, partnership status, education, employment status, income, health insurance status from ALP's generally-provided panelists' profiles at the time of the baseline survey (wave 7). SES is a multidimensional concept that encompasses many individual characteristics such as education, employment and income.[59,60] While the exact measurement of SES often depends on the application and data at hand, education is often seen as a leading indicator among the various SES components, especially in models of health behaviors.[5-7,13-16,19] Given its special role in determining health behaviors, I used education as my leading SES indicator. I classified respondents into one of three categories based on their highest level of completed education; (1) a high school degree or less (2) a college degree or equivalent qualification (3) a Master degree or more. Employment status, in turn, indicated whether the respondent was working, while family income was measured based on a binary indicator for total annual family income of USD 60,000 or more. The survey also measured respondents' health insurance status at baseline.

The final study sample consisted of a balanced panel of 1,559 persons who responded to all items used in my analysis from all of the above three surveys. Table 1 presents sample means for all variables for both the full sample and the subsample of respondents who were specifically recommended for H1N1 vaccination. The RAND Corporation's institutional review board approved the study design and survey questionnaires. Respondents' participation in the surveys was voluntary.

I used nonparametric kernel regressions to provide first descriptive evidence on the bivariate relationship between initial vaccination intentions and later vaccine uptake. The employed kernel-weighted local mean smoothing techniques provide nonparametric estimates of the proportion of respondents who were vaccinated at the end of the pandemic as a function of respondents' initial vaccination intentions by computing locally smoothed means of vaccine

uptake for respondents with different levels of self-reported behavioral intentions to get vaccinated.[61-63] These nonparametric regressions were performed separately for the full sample and specific subsamples defined by respondents' H1N1 vaccination recommendation status and SES indicators. To address potential issues of confounding, I employed multivariable linear regressions to estimate adjusted associations between perceived H1N1 risks and H1N1 vaccination intentions on the one hand and respondents' characteristics on the other. H1N1 vaccine uptake, in turn, was analyzed using nonlinear probit models. As these were intended to estimate individual behavioral relationships rather than (sub-)population means and employed a rich set of sociodemographic controls, I did not employ individual survey weights.[64]

Results

Figure 1 presents nonparametric regression estimates of H1N1 vaccine uptake on behavioral vaccination intentions prior to vaccine availability, for the full sample and by H1N1 vaccination recommendation status. By plotting the 45-degree line, the figure also highlights mean deviations of actual vaccine uptake at the end of the pandemic from expected mean vaccination rates if all respondents would follow through on their initial vaccination plans as a function of their initially stated vaccination intentions. Specifically, the nonparametric estimates should coincide with the 45-degree line if individuals' vaccination intentions are on average fully accurate predictors of later vaccination behavior. Similarly, the estimates would fall above (below) the 45-degree line if intentions were—on average—understating (overstating) respondents' follow through on their initial vaccination plans.

The monotonically increasing nonparametric regression estimates of Figure 1 show that H1N1 vaccination intentions were positively related with later vaccine uptake. However, the figure also shows that respondents' initial vaccination intentions were on average overstating their future chances to get vaccinated, as the regression estimates were generally below the 45-degree line. For example, respondents who reported a 40 percent chance of getting vaccinated prior to the availability of H1N1 vaccine only had an average vaccine uptake of about 20 percent at the end of the pandemic. Overall, a one percentage point increase in behavioral vaccination intentions was only associated with an average increase in later vaccine uptake of 0.44 percentage points. I obtained similar patterns for persons with and without a specific government H1N1 vaccination recommendation, though the overall level of follow through on initial vaccination plans was always higher for persons who were covered by such a vaccination recommendation.

Figure 2 presents analogous estimates for different SES groups defined by education, employment, family income and health insurance status. Behavioral intentions predicted later H1N1 vaccination for all SES groups, even if vaccination intentions generally overstated subsequent vaccine uptake. Higher SES groups had generally higher levels of follow through on initial vaccination plans, with the exception of working respondents. The exact pattern of follow through on initial vaccination plans differed somewhat by SES indicator: Respondents with higher education and income had higher levels of follow through at both low and high levels of self-reported vaccination intentions. Differences in follow through by education and income were smaller at intermediate intention levels,

reaching their minimum at initial vaccination intentions of around 40 percent. Respondents with health insurance had consistently higher levels of follow through than uninsured persons. Finally, non-working respondents had higher levels of follow through than working persons except at very high levels of initial vaccination intentions.

Table 2 presents estimates from multivariable models analyzing the partial associations of SES, demographic characteristics, and H1N1 vaccination recommendations with perceived H1N1 risks and behavioral vaccination intentions prior to vaccine availability. Columns 1 and 2 of Table 2 show that risk perceptions were lower among higher SES groups. Whenever statistically significant, the partial associations of perceived H1N1 risks with education, employment and family income were negative. Only health insurance coverage displayed positive, but insignificant partial associations with perceived H1N1 risks. Holding other characteristics fixed, older respondents, females and singles perceived H1N1 as more risky than younger persons, males and partnered individuals. These patterns were, however, not always statistically significant. Racial and ethnic minorities and respondents recommended for H1N1 vaccination reported significantly higher perceived H1N1 risks than non-Hispanic whites and persons without a specific vaccination recommendation.

Columns 3 and 4 of Table 2 present the partial associations of respondents' SES, demographic characteristics and H1N1 vaccination recommendation status with self-reported behavioral vaccination intentions for H1N1 influenza. Column 3 uses the same control variables as the previous models for perceived H1N1 risks, while column 4 is based on an extended model that also included the two H1N1 risk measures as controls. Despite their lower risk perceptions, persons with higher education and health insurance reported significantly higher behavioral intentions to get vaccinated for H1N1 prior to vaccine availability. Working respondents, on the other hand, reported significantly lower vaccination intentions. Age and coverage by a H1N1 vaccination recommendation also displayed significant positive partial associations with vaccination intentions. Incorporating the perceived risk measures into the statistical model for behavioral vaccination intentions produced largely comparable results with the exception of newly significant socio-demographic differences in vaccination intentions by income and race (African American). The perceived risk measures themselves displayed strong and significant positive associations with stated H1N1 vaccination intentions.

Table 3 presents estimated average partial effects from probit models for H1N1 vaccine uptake at the end of the pandemic (May/June 2010) using gradually expanding sets of control variables. Persons with higher education and health insurance coverage were significantly more likely to be vaccinated, irrespective of whether or not perceived H1N1 risks and/or initial behavioral vaccination intentions were directly controlled for. Having a partner and being recommended for vaccination also always displayed significant positive partial associations with H1N1 vaccination. Contrasting Models 1 and 2, which do not incorporate behavioral intentions to get vaccinated, with Models 3 and 4, which control for individual differences in initial vaccination intentions, delivers further insights into the role of stated intentions vs. differences in follow through on initial vaccination plans for SES differences in H1N1 vaccine uptake at the end of the pandemic.

Models 1 and 2 assess the partial associations of respondents' characteristics with H1N1 vaccination with and without direct controls for individuals' risk perceptions, but without controlling for vaccination intentions. Corresponding estimates of SES differences in H1N1 vaccine uptake thus embody both SES differences in intentions to get vaccinated as well as potential SES differences in follow through on initial vaccination plans. Models 1 and 2 produced similar estimates with significant positive partial associations for education and health insurance status and negative, but only marginally significant partial associations for employment. Age, having a partner, being recommended for H1N1 vaccination and perceived infection risks (Model 2) also displayed significant positive partial associations with vaccination.

Adding behavioral vaccination intentions into these models to isolate potential SES differences in follow through on initial vaccination plans (Model 3 and 4) reduced, but did not eliminate the partial associations between vaccine uptake and SES. Education and health insurance status remained significant predictors of H1N1 vaccination as did partnership status and vaccination recommendation status. Stated vaccination intentions themselves displayed significant positive associations with subsequent H1N1 vaccination: A one percentage point increase in the self-reported intention to get vaccinated was associated with a 0.38 percentage point increase in vaccine uptake at the end of the pandemic. Yet follow through on initial vaccination plans was generally limited, as already indicated in Figures 1 and 2. These results obtained irrespective of whether the models accounted for perceived influenza risks. Rather, individual risk perceptions did not enter the model significantly once vaccination intentions were directly accounted for (Model 4). Importantly, the differences in the estimates between Models 1 and 2 and Models 3 and 4 further highlight that SES differences in behavioral vaccination intentions explained only part of the overall SES differences in later vaccination, despite the strong predictive power of initial vaccination intentions for later vaccine uptake. Rather, the results of Models 3 and 4 reveal significant SES differences in follow through on initial vaccination plans with generally higher levels of follow through among higher SES respondents.

Largely similar findings also obtained when focusing the analyses on particular subpopulations of interest such as respondents specifically recommended for H1N1 vaccination and persons with health insurance. Appendix Tables A1 and A2 report the same estimations as Tables 2 and 3, but only for respondents with a H1N1 vaccination recommendation. While higher education was still associated with lower risk perceptions in this sample, behavioral intentions to get vaccinated did not display any significant partial association with education, but only with health insurance status. Vaccine uptake, however, remained significantly positively associated with education and health insurance status in all models. However, some partial associations—especially the one with health insurance status —attenuated once vaccination intentions were directly accounted for. Appendix Tables A3 and A4 repeat the same estimations focusing only on respondents with health insurance. As in the benchmark analyses, education and income was significantly negatively associated with risk perceptions, but positively associated with behavioral vaccination intentions. Behavioral intentions were also significantly higher among non-working and older persons and individuals with a specific vaccination recommendation. Finally, the estimation results

for vaccine uptake among insured respondents closely resembled those for the full sample of Tables 2 and 3.

Discussion

I documented significant SES differences in H1N1 vaccination behavior among U.S. adults during the 2009-10 influenza pandemic. In line with previous evidence from a non-pandemic influenza season[40], I found sizable differences between stated vaccination intentions prior to vaccine availability and later vaccine uptake, indicating significant lack of follow through on initial vaccination plans. Although SES differences in behavioral vaccination intentions played an important role for later SES differences in H1N1 vaccination, these differences in vaccination intentions explained only part of the overall SES disparities in vaccine uptake. While the inclusion of behavioral intentions into a model for H1N1 vaccination led to some attenuation of the relationship between SES and vaccine uptake, education and health insurance status remained significant predictors of H1N1 vaccination, even after accounting for differences in initial vaccination intentions. The relationship between SES and vaccination behavior was therefore only partially mediated via SES differences in behavioral vaccination intentions. This result points toward other important barriers to influenza vaccination, such as lower levels of self-control or unexpected barriers to accessing influenza vaccine among lower SES groups, which lead to lower levels of follow through on initial vaccination plans for these groups. These findings obtained despite higher risk perceptions for H1N1 influenza among lower SES individuals.

Stated vaccination intentions appeared nonetheless useful for summarizing individuals' knowledge, attitudes, beliefs and perceived behavioral control with regard to later vaccination. In line with previous evidence[45,65], perceived H1N1 risks—as a motivating factor for getting vaccinated—displayed significant positive associations with self-reported vaccination intentions. Yet these risk measures did generally not have any significant effects on H1N1 vaccination, once behavioral vaccination intentions were directly accounted for. Behavioral vaccination intentions, in turn, were strongly associated with later vaccination, despite significant gaps in follow through on initial vaccination plans. This limited follow through on initial vaccination plans points toward unanticipated issues of behavioral control or unexpected access barriers to vaccination[39,40], especially among low SES persons.

My study suffers from several limitations. First, the data were collected using the Internet as a survey mode and the analysis only used respondents with complete information from all three survey waves, which may have resulted in biased estimates if survey participation is systematically related to study outcomes. Second, the analysis used self-reported data, which may not be accurate. For example, self-reported vaccination status may be subject to “self-generated validity”, which may inflate the association between stated intentions and subsequent behavior.[66] However, my longitudinal data were collected in near real-time, which should minimize both recall and justification biases compared to retrospective assessments within a single survey. Thirdly, while the survey elicited behavioral vaccination intentions just prior to the availability of H1N1 vaccine, individual vaccination plans may have changed over time.[58] Some evidence suggests that at least part of the relatively low association between vaccination intentions and later vaccine uptake may have been due to

continued downward revisions of perceived H1N1 risks and vaccination intentions through the pandemic.[56,67] If these revisions differ by SES, they could also explain SES differences in follow through on initial vaccination plans irrespective of potentially lower levels of self-control and higher unanticipated barriers to vaccination among lower SES groups. Finally, I assessed the relationship between vaccination intentions and later vaccination during a pandemic and my results may not generalize to non-pandemic influenza seasons.

Conclusion

SES differences in influenza vaccination are an important public health concern. Behavioral intentions to get vaccinated are generally positively associated with SES, despite higher perceived influenza risks among lower SES groups. These SES differences in vaccination intentions are likely to reflect SES differences in vaccination-related knowledge, attitudes and beliefs and/or perceived access barriers to get vaccinated and are a contributing factor to later SES differences in vaccine uptake. By contrast, employment was negatively associated with behavioral vaccination intentions, which points to potentially important time constraints in shaping influenza vaccine uptake.

SES differences in follow through on initial vaccination plans were another important factor underlying later SES differences in H1N1 vaccination. This finding suggests significant unforeseen issues of behavioral control or barriers to vaccine access, especially among lower SES groups. The large importance of health insurance status for both vaccination intentions and follow through on initial vaccination plans further highlights the key role of (foreseen and unforeseen) barriers to healthcare access for influenza vaccine uptake. Increasing vaccine uptake and alleviating corresponding disparities by SES thus requires not only strategies to improve knowledge, attitudes and beliefs regarding influenza vaccinations, but also efforts to facilitate follow through on initial vaccination plans by improving vaccine access and behavioral control, especially for lower SES persons, working individuals and persons without health insurance. Targeted communication efforts by healthcare providers and public health information campaigns as well as supply-side interventions such as worksite vaccination clinics, routine vaccination offers during healthcare visits or other interventions that increase access to and convenience of vaccine uptake may be promising starting points.[25,68-76]

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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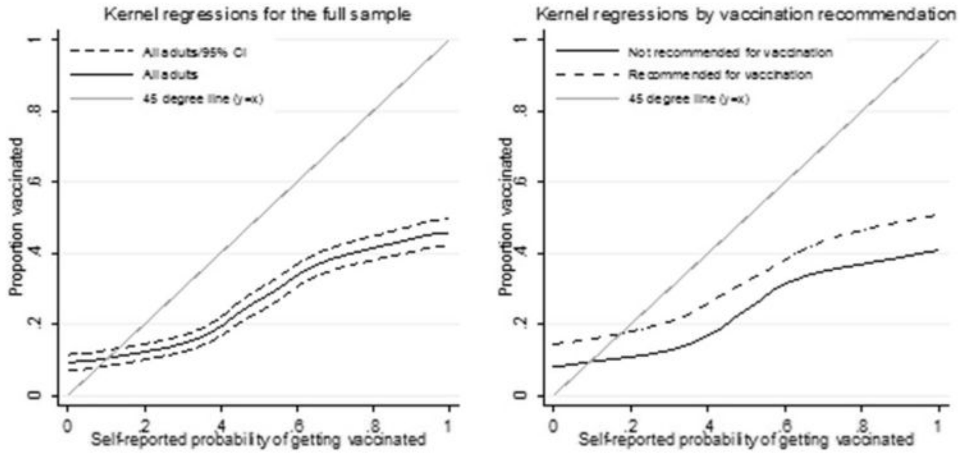

Figure 1.

H1N1 vaccination intentions and subsequent vaccine uptake for the full sample and by H1N1 vaccination–recommendation status. U.S. adults. May-June 2010. N=1,559. Kernel regressions (local mean smoothing) of H1N1 vaccine uptake on previously reported vaccination intensions using unweighted data.

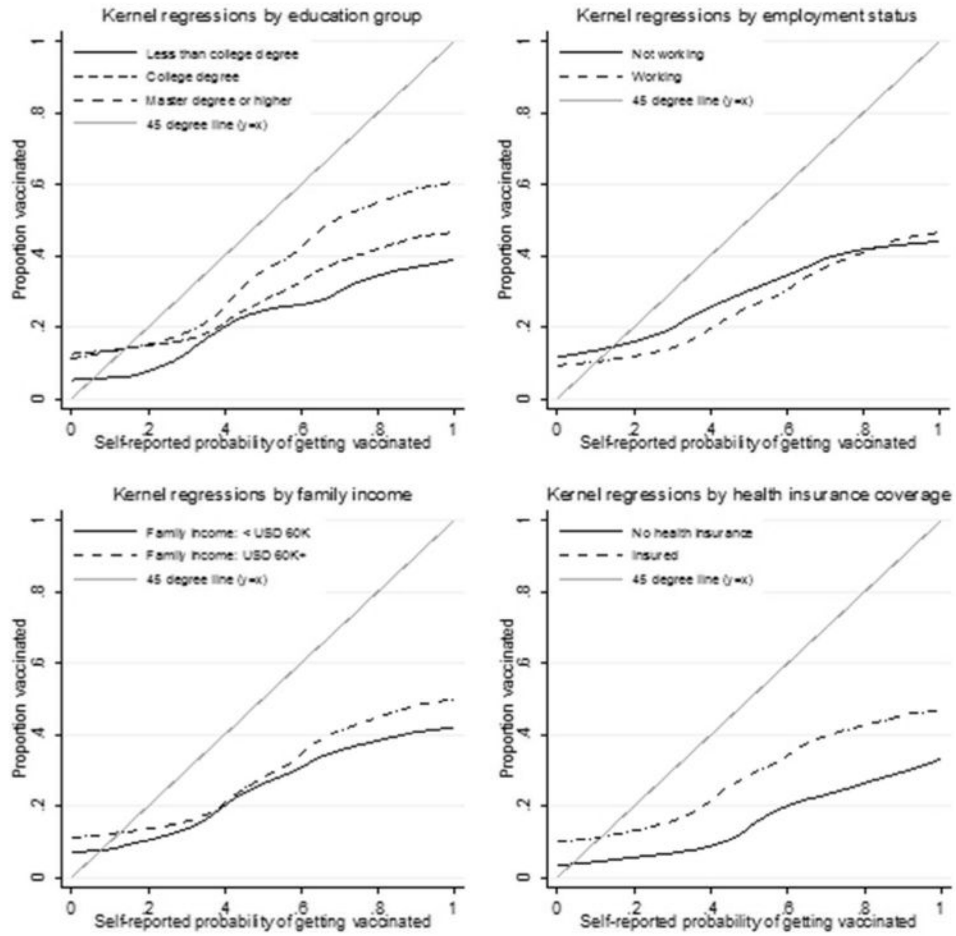

Figure 2.

H1N1 vaccination intentions and subsequent vaccine uptake by socioeconomic status. U.S. adults. May-June 2010. N=1,559. Kernel regressions (local mean smoothing) of H1N1 vaccine uptake on previously reported vaccination intensions using unweighted data.

Table 1

Sample means. U.S. adults. August 2009 - June 2010N=1,559

Variable	Full sample (N=1,559)	Respondents covered by a government H1N1 vaccination recommendation (n=531)
Outcome variables		
H1N1 vaccine uptake	0.26	0.33
H1N1 vaccination intention at baseline (in %)	46.52	51.06
Perceived H1N1 risk at baseline: Infection next month (in %)	10.80	12.38
Perceived H1N1 risk at baseline: Death if infected (in %)	11.00	13.82
Socioeconomic control variables		
Education: Less than college degree or equivalent	0.44	0.43
Education: College degree or equivalent	0.37	0.38
Education: Master degree or higher	0.19	0.19
Employment status: Working	0.71	0.73
Family income: USD 60K+	0.48	0.46
Health insurance status: Insured	0.89	0.89
Demographic control variables		
Age	51.67	47.51
Sex: Female	0.57	0.62
Family status: Partnered	0.67	0.62
Race/ethnicity: African American	0.05	0.07
Race/ethnicity: Hispanic	0.03	0.04
Race/ethnicity: Non-hispanic white	0.89	0.86
Race/ethnicity: Other/mixed	0.02	0.04
H1N1 risk control variable		
Covered by H1N1 vaccination recommendation	0.34	1.00

Notes: Unweighted data.

Table 2

Multivariable regressions for H1N1 risk perceptions and vaccination intentions. U.S. adults. August 2009. N=1,559

	Perceived risk		Vaccination intentions w/o and with controls for perceived risk	
	Infection next month	Death if infected		
Control variables	Coefficient [t-statistic]	Coefficient [t-statistic]	Coefficient [t-statistic]	Coefficient [t-statistic]
Socioeconomic controls				
Education: College degree or equivalent	-2.6 1 ** [-3.00]	-3.0 6 ** [-3.27]	3.7 3 + [1.72]	6.19 ** [3.03]
Education: Master degree or higher	-2.68 ** [-2.68]	-4.15 *** [-3.90]	5.75 * [2.12]	8.43 ** [3.29]
Employment status: Working	-0.25 [-0.27]	-2.65 * [-2.30]	-7.11 ** [-3.00]	-6.51 ** [-2.92]
Family income: USD 60K+	-2.17 * [-2.58]	-3.52 *** [-3.64]	1.94 [0.91]	4.14 * [2.03]
Health insurance status: Insured	2.08 [1.54]	1.52 [0.91]	7.85 * [2.56]	6.03 * [2.19]
Demographic controls				
Age	0.0 8 * [2.39]	0.0 7 * [1.96]	0.69 *** [9.04]	0.62 *** [8.73]
Sex: Female	1.28 + [1.68]	0.18 [0.21]	-0.51 [-0.26]	-1.51 [-0.83]
Family status: Partnered	-0.29 [-0.32]	-1.78 + [-1.67]	2.85 [1.29]	3.35 [1.63]
Race/ethnicity: African American	7.78 *** [3.44]	10.69 *** [3.75]	-2.14 [-0.50]	-9.72 * [-2.54]
Race/ethnicity: Hispanic	5.85 * [2.29]	5.33 * [2.04]	3.69 [0.71]	-1.59 [-0.33]
Race/ethnicity: Other/mixed	3.07 [0.99]	-0.9 [-0.38]	-2.91 [-0.48]	-5.09 [-0.81]
H1N1 risk				
Recommended for H1N1 vaccination	2.41 ** [2.95]	4.34 *** [4.69]	11.79 *** [5.80]	9.28 *** [4.81]
H1N1 risk perceptions at baseline				
Infection next month (in %)	---	---	---	0.76 *** [11.29]
Death if infected (in %)	---	---	---	0.16 * [2.33]
Intercept	5.7 4 * [2.23]	10.1 6 ** [3.13]	0.1 8 [0.03]	-5. 77 [-1.12]

Notes: Coefficients of multivariable regression models using robust standard errors.

+ p<0.10;

* p<0.05;

** p<0.01;

*** p<0.001.

Omitted reference categories are “less than a college degree”(education), “not working”(employment), “family income less than USD 60K+ (family income), “uninsured” (health insurance status), “male” (sex), “single” (family status), “white” (race/ethnicity), “not recommended for H1N1 vaccination” (H1N1 risk).

Table 3

Average partial effects (APE) of Probit models for H1N1 vaccine uptake. U.S. adults. May-June 2010. N=1,559

	H1N1 Vaccine Uptake			
	Model 1	**Model 2**	**Model 3**	**Model 4**
Control variables	**APE [t-statistic]**	**APE [t-statistic]**	**APE [t-statistic]**	**APE [t-statistic]**
Socioeconomic controls				
Education: College degree or equivalent	7.03 ** [2.89]	7.86 ** [3.24]	5.91 ** [2.58]	5.7 3 * [2.50]
Education: Master degree or higher	14.84 *** [4.50]	15.61 *** [4.74]	12.39 *** [4.14]	12.13 *** [4.03]
Employment status: Working	-5.02 + [-1.95]	-4.98 + [-1.93]	-2.1 [-0.88]	-2.24 [-0.93]
Family income: USD 60K+	0.31 [0.13]	1.02 [0.42]	-0.61 [-0.27]	-0.85 [-0.37]
Health insurance status: Insured	12.22 ** [2.95]	11.71 ** [2.85]	8.90 * [2.32]	8.87 * [2.32]
Demographic controls				
Age	0.25 ** [2.88]	0.23 ** [2.60]	-0. 04 [-0.44]	-0. 03 [-0.41]
Sex: Female	-2.39 [-1.09]	-2.77 [-1.27]	-2.51 [-1.24]	-2.53 [-1.24]
Family status: Partnered	5.97 * [2.34]	6.09 * [2.40]	4.84 * [2.06]	4.74 * [2.01]
Race/ethnicity: African American	-0.56 [-0.11]	-2.76 [-0.53]	-0.62 [-0.13]	-0.14 [-0.03]
Race/ethnicity: Hispanic	0.09 [0.01]	-1.69 [-0.28]	-0.4 [-0.07]	-0.25 [-0.04]
Race/ethnicity: Other/mixed	-8.9 [-1.51]	-9.74 + [-1.67]	-8.63 + [-1.65]	-8.74 + [-1.69]
H1N1 risk				
Recommended for H1N1 vaccination	12.50 *** [5.64]	11.81 *** [5.30]	7.96 *** [3.84]	8.12 *** [3.89]
H1N1 risk perceptions at baseline				
Infection next month (in %)	---	0.30 *** [3.60]	---	0.0 3 [0.32]
Death if infected (in %)	---	-0.02 [-0.20]	---	-0.07 [-0.89]
Behavioral intention				
H1N1 vaccination intention at baseline (in %)	---	---	0.38 *** [16.63]	0.38 *** [15.91]

Notes: Estimated average partial effects (APE)*100 of multivariab le probit models u sing unweighted data.

+ p<0.10;

* p<0.05;

** p<0.01;

*** p<0.001.

Omitted reference categories are “less than a college degree”(education), “not working”(employment), “family income less than USD 60K+ (family income), “uninsured” (health insurance status), “male” (sex), “single” (family status), “white” (race/ethnicity), “not recommended for H1N1 vaccination” (H1N1 risk).