Influenza Vaccination Disparities in Chronically-ill US Adults: An Intersectionality Approach

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Abstract

Adult influenza vaccination rates in the U.S. reveal well-documented, persistent disparities among disadvantaged social statuses of race/ethnicity, and some evidence by sex/gender and SES. By comparison, nothing is known about the synergistic effects of holding *multiple* such statuses on influenza vaccination disparities. Guided by intersectionality theory, we address this gap using the 2011-2012 Aligning Forces for Quality Consumer Survey (n=7,176), data representative of chronically-ill US adults living in diverse healthcare markets that contain roughly 12.5% of Americans and containing key variables related to health services use. We use the linear probability regression model to estimate the effects of and interactions between race/ethnicity, sex, and education on influenza vaccination. Most importantly, our findings provide strong evidence that not accounting for interacting social statuses masks the intensity and patterns of influenza vaccination disparities among jointly disadvantaged persons. As an example of masking intensity, even though there were no significant racial/ethnic, sex or education disparities when they were considered alone (additive model), Hispanic men without a four-year college degree were roughly *half* as likely to be vaccinated as non-Hispanic Whites of *any* sex or educational attainment in the intersectionality model (predicted probabilities of 0.310 vs. 0.567-0.667, all $p<0.05$). We found two significant moderating patterns in the interaction between these social statuses and influenza vaccination. First, race/ethnicity moderates the relationship between sex and vaccination. The large sex gap in influenza vaccination uptake among Hispanics did not appear in other races/ethnicities; further research understanding differences in vaccine uptake factors between Hispanic males and females is needed. Second, there is significant triple interaction. Only among non-Hispanic Whites did both sexes have higher vaccination uptake in college-educated respondents, suggesting that something about the attainment of college education is different in minorities and may contribute to disparities in influenza vaccination and perhaps other health and health services outcomes.

Research highlights

- Race/ethnicity, sex, and education interact to affect flu vaccination disparities
- Those with multiple disadvantaged social statuses had largest vaccine disparities
- Hispanic males without college degrees were least likely to be vaccinated
- Only in Whites did college education increase flu vaccine uptake in both sexes
- Minorities may benefit less from college education, widening flu vaccine gaps

Keywords
Vaccination; healthcare disparities; intersectionality; race and ethnicity; sex or gender; educational attainment; social determinants of health; United States

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Introduction

Background

Other than safe water, no public health intervention has had a greater effect on population growth and mortality reduction than vaccination (Plotkin, Orenstein, & Offit, 2008). A vaccine-preventable disease of particular importance is influenza, which results in up to 200,000 hospitalizations (Thompson et al., 2004), and 49,000 deaths (Centers for Disease Control and Prevention [CDC], 2011) in the U.S. each year. Additionally, influenza puts tremendous burden on the U.S. economy: Molinari et al. (2007) estimate an annual cost of $87 billion. The CDC recommends all persons over 6 months receive influenza vaccination each year as the most effective means of prevention (CDC, 2012, 2014). Despite influenza's burdens and the wide availability of safe, effective, and cheap (often free) influenza vaccines, well-established adult influenza vaccine programs in the U.S. have not achieved optimal coverage (Setse et al., 2011). Adult influenza vaccination rates have generally not increased since the late 1990's (Lu, Bridges, Euler, & Singleton, 2008) and remain well below federal objectives (Lu, Singleton, Euler, Williams, & Bridges, 2013; U.S. Department of Health and Human Services, 2012).

Moreover, U.S. influenza vaccination rates exhibit persistent disparities that remain even controlling for numerous factors (CDC, 2003). Disparities in receipt of healthcare have significant implications for healthcare providers, administrators, policymakers, and consumers, and hinder efforts to improve the nation's health overall (Smedley, Stith, Nelson, & Institute of Medicine, 2003). In this study, we examine disparities in influenza vaccination among chronically-ill adults – a population at increased risk for severe influenza illness or death (CDC, 2013), grounding our empirical methodology in intersectionality theory. With origins in black Feminist philosophy, intersectionality theory posits that one must account for how various systems of oppression interact to produce and perpetuate inequality (Crenshaw, 1989). We believe that intersectionality theory will provide a more thorough understanding of persistent disparities in influenza vaccination.

Disparities in influenza vaccination by race/ethnicity

In the US, racial/ethnic disparities in influenza vaccination are well-documented and persistent. For example, for adults 65 years and older, uptake for non-Hispanic Blacks and Hispanics was lower than non-Hispanic Whites for the entire periods of 1989-2001 (CDC, 2003), and 2000-2010 (Setse et al., 2011). Disparities in adults under 65 are less well-documented but similar, in both those with (Egede & Zheng, 2003) and without (Lu et al., 2013) high-risk conditions. Many conditions increasing the risk of severe influenza illness or death are more prevalent among minorities (Hutchins, Fiscella, Levine, Ompad, & McDonald, 2009), making influenza disparities between chronically-ill minorities and non-minorities particularly important. According to conservative estimates, elimination of disparities in older Blacks and Hispanics in the US would prevent 1,880 minority deaths – 33,000 minority years of life – each year (Fiscella, Dressler, Meldrum, & Holt, 2007).

Disparities in influenza vaccination by sex/gender

Studies of influenza vaccination generally control for sex/gender but few studies explicitly examine them as variables of interest. A review of literature published from 1980-2011 on influenza vaccination determinants among older adults found that males were often more likely to be vaccinated, though the literature is inconclusive – sometimes differences were insignificant, or moderated by age (Nagata et al., 2013). Results from additional studies we found not included in this review were also mixed, with sex/gender disparities varying across differing populations and contexts (Bean-Mayberry et al., 2009; Jiménez-García et al., 2010; Mamelund & Riise Bergsaker, 2011; Vaidya et al., 2011; World Health Organization [WHO], 2010). Each sex has unique reasons placing them at risk. Men face higher influenza exposure rates overall (Klein, 2012), though women are more likely to work in caregiving or healthcare occupations which carry increased risk of exposure (WHO, 2010). Further, pregnancy can worsen influenza illness and alter immune response to the vaccine, putting mothers and fetuses at additional risk (WHO, 2010).

Disparities in influenza vaccination by SES

Similarly, measures of SES are usually controlled for in studies of influenza vaccination but not typically studied as determinants of interest (Coupland et al., 2007; Endrich, Blank, & Szucs, 2009; Setse et al., 2011). The aforementioned review by Nagata et al. (2013) found that lower SES (measured in the literature as education, income, occupation, highest individual class within the household, or deprivation index) was generally associated with lower uptake, though some studies found no association and a couple even found the reverse association in contexts where the vaccine was administered by the government, free of charge, or in multiple settings. Additional literature we found not included in this review supports these nuances: lower SES is typically associated with lower influenza vaccination uptake in most settings (Coupland et al., 2007; Wershof Schwartz et al., 2013), though this can be moderated by factors such as age and geography (Endrich et al., 2009; Jones, Ingram, Craig, & Schaffner, 2004). These disparities are particularly important given that reduced vaccination amongst lower income populations can fuel influenza epidemics even when wealthier areas nearby receive timely and abundant vaccination (Lee et al., 2011). Further, SES gradients in influenza vaccination can persist through generations of increased educational attainment (Uddin et al., 2010); understanding the nuances of how education affects vaccination disparities is particularly important.

Intersectionality theory and its application to the study of vaccination

Prior health research has tended to treat disadvantaged social statuses as separate entities, potentially obscuring important differences in health and undermining efforts to reduce health disparities (Warner & Brown, 2011). Intersectionality theory directly addresses this issue, positing that social statuses like race/ethnicity, gender, and social class intersect to shape a variety of outcomes (Collins, 1990, 2000) and cannot be disaggregated as they reinforce each other in producing and maintaining health across the life span (Dill & Zambrana, 2009; Schulz & Mullings, 2006). Intersectionality theory has greatly enhanced the understanding of health outcomes (Warner & Brown, 2011).

To the best of our knowledge, intersectionality theory has not been applied to examine interacting, multiplicative effects of race/ethnicity, gender/sex, and SES on influenza vaccination. An intersectional approach *has* been applied in studies examining other vaccinations, though in very few – mostly in settings with limited generalizability to US adults. For example, Joe (2014) examined intersections of gender, place, and caste in India, finding that the lower likelihood of receiving a full series of recommended vaccinations among children of low caste and those living in rural areas was buffered for males, a finding only uncovered via an intersectional approach. Branković, Verdonk, & Klinge (2013) applied intersectionality theory to review and understand literature on the role gender plays in HPV vaccination, finding that less educated, older, and sexual minority women had lower uptake. Taken together, the literature provides rationale for the added value of examining intersections of various identities and social positions when explaining disparities in influenza vaccination.

Methods

Data source

Data used in this study come from the Aligning Forces for Quality (AF4Q) initiative. AF4Q is the Robert Wood Johnson Foundation's (RWJF's) "signature effort" to improve overall quality of care in targeted communities that are geographically, demographically, and economically diverse (AF4Q, 2013). The RWJF provides funds and technical assistance to 17 multi-stakeholder alliances that service these communities to address five main programmatic areas, one of which is particularly relevant to this study – ensuring equitable receipt of healthcare and reducing racial and ethnic disparities. These alliances are diverse in representation, including whole states (e.g., Maine, Wisconsin), counties (e.g., Humboldt County, CA), metropolitan areas (e.g., Cleveland, Greater Boston, Kansas City) and mostly rural areas (e.g., New Mexico, Humboldt County) and their constituents comprise roughly an eighth of the US population [for more details on AF4Q, see Scanlon, Beich, et al. (2012)].

The RWJF dedicates funding for an independent, impartial scientific evaluation of AF4Q [for more details on the evaluation, see Scanlon, Alexander, et al. (2012)]. The specific data for this study come from one of the evaluation's surveys – the Consumer Survey (CS) – which has a target population of US adults (18 years or older) with at least one of five chronic conditions (asthma, depression, diabetes, heart disease, and hypertension). This target population is considered high-risk for developing influenza-related complications (CDC, 2013). The CS was conducted for samples from AF4Q communities and a national comparison sample using Random Digit Dial. The sample weights used in this study were constructed to be representative of chronically-ill persons in these diverse health markets (RTI International, 2013). Survey questions focus on patient activation; consumer knowledge of publicly available healthcare quality performance reports; the ability to be an effective healthcare consumer during physician visits; patient knowledge about their illness; skills and willingness to self-manage illness; as well as other related topics (Scanlon, Alexander, et al., 2012). The first round of the CS was administered between July 2007 to August 2008, and the second round between July 2011 and November 2012 (RTI International, 2013).

The present study uses the most recent (Round 2) data. The response rate for this round was 39.7% (American Association of Public Opinion method) to 42.1% (Council of American Survey Research Organizations method) (RTI International, 2013). The CS response rate is consistent with the general response rates of other similar surveys (Bunin et al., 2007; Cull, O’Connor, Sharp, & Tang, 2005; Johnson & Wislar, 2012). Further discussions on the CS response rate and the issue of non-response can be found elsewhere (Scanlon, Shi, Bhandari, & Christianson, 2015). The CS contains a unique combination of variables identified in sections below to be conceptually and empirically crucial to one’s decision to vaccinate and to health disparities (e.g. perceived discrimination, patient activation).

Study sample

This study focuses on the "working sample" of 9,737 AF4Q CS Round 2 respondents. The working sample was restricted first to the original 15 sites (n=8,606) so that sample weights could be utilized to generate representative of chronically-ill persons in each healthcare market, i.e., representative of diverse parts of the US containing about 12.5% of the U.S. population. Then, it was further restricted to non-Hispanic White, non-Hispanic Black or African American, and Any Hispanic race/ethnicity due to small sample sizes in other races/ethnicities and to be comparable to other literature, equating to a total "analytic sample" of n=7,936. The main contributor to missing data was household income (3.9% of the analytic sample); all other variables were missing 1.5% or less of respondents. For fully-adjusted models, complete case analysis was used (n=7,176), leaving 760 respondents missing at least one variable from the full model (9.6% of the analytic sample). Compared to those in the complete case analytic sample, these 760 respondents did not significantly differ on influenza vaccination status and only differed on one variable of interest – they were more likely to be women.

Outcome and Main Independent Variables:

The outcome variable is a binary measure of self-reported *influenza vaccination* within the previous 12 months.

The main independent variables of interest are *race/ethnicity*, *sex* and *education.* To assess *race/ethnicity*, respondents were asked: "What race or races do you consider yourself to be?" and selected all applicable options: White (Caucasian); Black or African American; Asian; American Indian or Alaska Native; Native Hawaiian or Other Pacific Islander; Hispanic; or Other (specify). Very few respondents (3.6% of the working sample) selected more than one race; in these cases, they were assigned to a new "Multiracial" category. Respondents were also asked, "Are you of Hispanic or Latino origin or descent?" If respondents indicated Hispanic race they were also classified as being of Hispanic or Latino origin or descent ethnicity; 97.9% of persons indicating Hispanic race indicated yes to the ethnicity question. The variable used in this study is a mutually-exclusive version of these variables: non-Hispanic White (no other race indicated), non-Hispanic Black or African American (no other race indicated), or any Hispanic (indicated Hispanic ethnic respondents of any or multiple races). To assess *sex*, respondents indicated male or female. To assess *SES*, we captured attainment of at least a four-year college degree compared to less education. Education is but one dimension of *SES*, but we feel this measure is the best single dimension we have capturing *SES* given that education influences both occupation and income/wealth (Herd, Goesling, & House, 2007). The limitations of these measures are discussed in the Discussion section.

Covariates

The selection of covariates used in this study are grounded in Andersen's Behavioral Model of Health Services Use (Andersen, Rice, & Kominski, 2007), a conceptual model of individual- and contextual-level determinants of health services utilization. It divides individual-level determinants into three major components: (1) *predisposing factors* (e.g., age, sex, education, occupation, ethnicity, attitudes, values, knowledge related to health/health services); (2) *enabling factors* (e.g., income/wealth, health insurance, source of care); and (3) *need factors* (e.g., both objective and perceived measure of general health, functional state, and illness symptoms, need for medical care). The model also accounts for how intermediate-level individual health behavior influences health services use (e.g., personal health practices, the process of medical care). Andersen's model has been used extensively in studies investigating health services use across several realms of the healthcare system and in the context of a variety of diseases (Babitsch, Gohl, & von Lengerke, 2012).

From this model, we selected 15 covariates as important constructs for which to control. In some instances, related health behavior-level measures were combined in summative indices, a technique to maximize parsimony utilized with similar variables elsewhere in the vaccination literature (e.g., Farmer, Papachristou, Gotz, Yu, & Tong, 2010): (1) *age*; (2) *employment status*; (3) *poverty status* relative to the Federal Poverty Line (FPL); (4) *health insurance status*; (5) *smoking status*; (6) *experiences of perceived discrimination in healthcare due to race/ethnicity*; (7) *experiences of perceived discrimination in healthcare due to sex*; (8) *Patient Activation Measure (PAM) stage*, a scale reflecting engagement in one's own health (Hibbard, Stockard, Mahoney, & Tusler, 2004); (9) *health practices* index (range: 0-2, representing the number of the following diet and exercise recommendations to which the respondent conforms: regularly exercises, and eats at least 5 servings of fruit or vegetables most days of the week); (10) *quality of patient-provider relationship* index (range: 0-6, representing how strongly one agrees [strongly agrees is worth 2, agrees is worth 1, disagrees is worth 0] with the following statements: the provider explained things in a way they could understand; treated them with respect or dignity; and spent enough time with them); (11) *trust one has in information from their doctor* (1 is a lot, 2 a little, 3 not at all); (12) *self-rated health*; (13) *total number of chronic illnesses* (asthma, depression, diabetes, heart disease, and/or hypertension); (14) *number of visits to healthcare providers* to treat one's conditions, previous 3 months; and (15) *rating of all care received* from all healthcare professionals, previous 12 months.

Analysis

Bivariate associations between influenza vaccination status and each determinant were first examined using design-based F-tests for categorical variables and adjusted Wald tests for continuous/ordinal variables. We then examined how influenza vaccination relates to *race/ethnicity, sex,* and *education,* and other determinants, using multivariate regressions. As a baseline analysis, we first estimated a multivariate model without interaction terms.

As Veenstra (2013) discusses, however, main (additive) effects estimated from regression are neither useful nor appropriate from an intersectional perspective. Thus, to fully incorporate intersectionality theory, we examine multiplicative effects of race/ethnicity, sex, and education by adding hierarchical interaction terms (i.e., in addition to race/ethnicity, sex, and education, we include all two-way interaction terms – race/ethnicity*sex, race/ethnicity*education, and sex*education – and the three-way interaction term for race/ethnicity*sex*education).

Given that the focus of this study is on intersectionality, the key parameters of interest are the coefficients of interaction terms. Therefore, although the outcome is binary, we choose to use the linear probability model (LPM) using Ordinary Least Squares, instead of logistic regression, because logistic regression methods are not conducive to straightforward interpretation of multiplicative/interactive effects (Ai & Norton, 2003; Bauer, 2014). The LPM has been theoretically and empirically motivated in the literature (Aldrich & Nelson, 1984; Angrist, 2001; Heckman & Snyder, 1997), and used previously in numerous important studies (Angrist & Pischke, 2009; Currie & Gruber, 1996). Based on the estimates, we calculated marginal predicted probabilities of vaccination for all possible intersectional groups in the full model as well as their graphical representations. As a sensitivity analysis, we also compared the baseline

LPM (without interaction terms) with the corresponding logistical regression model. The results were similar.

All analyses were performed using State/SE 13.1 statistical software (StataCorp LP, 2013) and use Stata's *svy* commands to apply sample weights adjusting for complex survey design and heteroskedasticity.

Results

Approximately 57.0% of respondents reported receiving influenza vaccination in the previous 12 months. Table 1 contains weighted characteristics of the analytic sample.

Bivariate results

Table 2 describes weighted, bivariate associations of each determinant with influenza vaccination. In these unadjusted analyses, though there were no statistically significant sex disparities in influenza vaccination, there were significant disparities by race/ethnicity and by education: higher vaccine intake was observed in non-Hispanic Whites (58.6%) compared to non-Hispanic Blacks (47.9%) and Hispanics (47.9%) (p=0.032), and in respondents who attained a four-year college degree (64.4%) vs. those who had not (54.9%) (p=0.001). Higher vaccination uptake was also significantly associated with most other determinants: older age; retired employment status; income above the FPL; being currently insured; not being a current smoker; having no experiences of perceived racial/ethnic discrimination in the healthcare setting; having better diet and exercise practices; reporting higher patient-provider relationship quality; having a higher number of chronic diseases; having a higher number of recent visits to one's providers; and giving a higher rating of all care recently received.

Main (additive) LPM results

Model 1 of Table 2 shows results from the main (additive) LPM regression model. In these models, the inclusion of determinants of health services use controlled away the significant racial/ethnic disparities in influenza vaccination noted in the bivariate results, though the probability of influenza vaccination uptake was still marginally-significantly increased in individuals with attainment of a four-year college degree (+0.051 [95%CI -0.004, 0.111]). Change in probability of influenza vaccination was also associated with several other determinants. Probability was significantly higher in respondents who are 65 or older (+0.159 [0.094, 0.224]), currently insured (+0.204 [0.108, 0.300]), not currently smoking (+0.095 [0.020, 0.171]), follow recommended health practices (with each additional diet and exercise recommendation, +0.043 [0.006, 0.081]), have more chronic diseases (with each additional disease, +0.038 [0.008, 0.068]), and have a higher number of recent visits to see their provider (with each additional visit category, +0.022 [0.001, 0.042]). Probability was significantly lower in respondents who indicated "other" employment status (-0.083 [-0.163, -0.002]) relative to those employed full time.

Intersectional (multiplicative) LPM results

Model 2 of Table 3 applies intersectionality theory by adding to Model 1 all hierarchical interaction terms between race/ethnicity, sex, and education. Determinants significantly associated with higher or lower probability of influenza vaccination remained the same as in Model 1 and had very similar effect sizes so they are not reported here.

Model 2 does indicate significant intersectionality results given that one of the race/ethnicity categories and one of the interaction terms in the model are significant, though we do not report coefficient here because constitutive elements of interaction terms do not represent interpretable associations (Brambor, Clark, & Golder, 2006). To interpret them, our first step is to turn to Table 4 – Model 2-predicted marginal probabilities of influenza vaccination among all subgroups of all interaction terms (i.e., within each interaction term, the average values for all coefficients for all persons in each subgroup are used to predict the probability of influenza vaccination). By comparing the confidence intervals of predicted influenza vaccination probability within each intersectional group to find significantly different probability ranges, we find two sets of intersectional disparities. First, in the race/ethnicity*sex interaction term subgroups, Hispanic males have significantly lower predicted probability of vaccination (0.355 [0.235, 0.475]) compared to non-Hispanic white males (0.580 [0.534, 0.626]) and females (0.592 [0.556, 0.628]), and to non-Hispanic Black females (0.576 [0.489, 0.663]). Second, in the triple interaction group (subgroups of race/ethnicity*sex*education), Hispanic males without four-year college degrees have significantly lower predicted probability of vaccination (0.310 [0.171, 0.449]) than non-Hispanic Whites of *any* gender or educational attainment (predicted probability confidence intervals ranging from 0.520 to 0.726) and than non-Hispanic Black females without college education (0.589 [0.485, 0.692]). These disparities exist even though we did not observe significant disparities when examining *just* race/ethnicity, or sex, or education.

Figures 1 and 2 are graphical representation of the predicted probabilities among the two- and three-way interaction term subgroups, respectively. The plot of race/ethnicity*sex (Figure 1, upper-left panel) shows that there is a large sex gap in vaccination that does not appear to exist in any other race/ethnicity. There were no other significant disparities among two-term interaction term subgroups, though smaller patterns emerge in the other two plots in Figure 1 that could represent true findings in other studies with higher power – notably that, as it relates to the outcome of influenza vaccination, women may benefit more from attainment of a four-year college degree than men (upper right panel), and non-Hispanic Blacks may actually see worse vaccination outcomes with additional education attainment whereas other races see gains (bottom left panel). The triple interaction plot (Figure 2) shows that only among non-Hispanic Whites did both genders see vaccination benefits with attainment of a four-year college degree. In Hispanics, non-Hispanic men actually did see vaccination benefits from educational attainment, though their female Hispanic counterparts and both male and female non-Hispanic Blacks saw decreases upon such attainment.

Discussion

In our sample representative of 7,176 chronically-ill U.S. adults from a diverse set of healthcare markets that contains roughly an eighth of the U.S. population, we examined disparities in influenza vaccination with a focus on the intersectionality of race/ethnicity, sex, and education. This study is subject to several limitations. First, sample size considerations prevented stratifying the "any Hispanic" category, and prevented including respondents identifying as (non-Hispanic) Asian, American Indian/Alaska Native, Native Hawaiian or Other Pacific Islander, other race, or multiracial. Further, respondents chose from a list of specified categories despite that racial/ethnic identities are not fixed in individuals, though groups used in this study allow results to be comparable to other health disparities literature. Given these considerations, we made every effort to work within suggested guidelines for using race/ethnicity in biomedical publication (Kaplan & Bennett, 2003). Second, as noted by

Rosenfield (2012), there are multiple definitions and debates over measures of SES, class, and related terms. SES is likely a latent construct that requires a number of indicators to successfully quantify. For the purposes of this study, we utilized educational attainment for two reasons, as discussed in more detail in Herd, Goesling, & House (2007): first, education captures multiple SES components given that it influences occupation, which subsequently influences income/wealth; and second, education is more predictive than income of the onset of health problems, which is appropriate for our study given that influenza vaccination is meant to prevent influenza onset. We made a conscious effort to minimize these limitations and this study provides multiple contributions to the literature.

Additive findings

Considering only for a moment these social statuses separately for purposes of comparison to the literature reveals several findings. First, pertaining to racial/ethnic disparities, similar to what has been observed in the previous two decades (CDC, 2003; Setse et al., 2011), in our study non-Hispanic Blacks and Hispanics had gross vaccination uptake roughly 10 percentage points lower (statistically significant) than non-Hispanic Whites. These disparities have remained persistent in the literature after controlling for numerous sociodemographic characteristics (CDC, 2003). The causes are likely multifactorial and complex and research investigating possible mechanisms is limited (Fiscella et al., 2007; Logan, 2009), though Fiscella (2005) suggests several potential explanations: lower use of healthcare among minorities; worse health status and more comorbidities generally seen in minorities may compete for provider time and attention and cause less preventive care provision; greater distrust of physicians among minorities (particularly African Americans); an unconscious racial bias among physicians resulting in differential health service provision; and perhaps even a general tendency of minorities' physicians to provide less preventive services for no other reasons. Our study contained constructs controlling for almost all of these explanations, which may explain why racial/ethnic disparities disappeared in the multivariate, additive model.

Second, there was no significant sex difference in influenza vaccination our study, adding to many studies finding no such difference. Women have a greater protective immune response to the vaccine (Klein, Passaretti, Anker, Olukoya, & Pekosz, 2010), tend to have increased levels of ambulatory healthcare utilization (NCHS, 2001), and outperformed men in a majority of Health People 2010's Leading Health Indicators – suggesting they would be more likely to be vaccinated – but they lagged behind men in the influenza vaccination indicator (Maiese, 2002). Clearly, a better understanding of how sex and gender influence influenza infection and vaccination is needed (WHO, 2010).

Finally, obtaining a four-year college degree was marginally associated with about a 5% increase in predicted probability of influenza vaccination in the additive model. Persons with lower levels of education are less likely to have access to regular preventive healthcare or to resources to overcome barriers, to be aware of healthy lifestyles, to ask physicians about vaccination, and to have the health literacy needed to use those resources to make appropriate health decisions (Nagata et al., 2013). Extending to the literature on SES defined more broadly, differences in influenza vaccination rates among those with low SES may be explained by differences in health beliefs and attitudes, reduced ability to seek assistance and information, increased concerns regarding vaccine safety and efficacy, and shortages of physician time and health services power in the community (Armstrong, Berlin, Schwartz, Propert, & Ubel, 2001; CDC, 2005; Damiani, Federico, Visca, Agostini, & Ricciardi, 2007; Hebert et al., 2005; Nowalk, Zimmerman, Tabbarah, Raymund, & Jewell, 2006; Redelings et al., 2012; Szucs & Müller, 2005; Zimmerman et al., 2009), though we controlled for many related measures.

Among other determinants, influenza vaccination was significantly associated with a few constructs that the Behavioral Model of Health Services Use would predict enables, predisposes, or creates need for health services use: older age, non-smoking status, following recommended health practices, having more chronic diseases, and having a higher number of recent visits to one's healthcare provider. These findings are also generally supported by the extant literature.

Intersectional findings

The most important finding of this paper is that including multiplicative interactions of disadvantaged social statuses in models examining disparities revealed important disparities and patterns lessened or totally hidden in the additive models. Our study adds evidence to intersectionality theory literature suggesting that social disadvantages statuses cannot be disaggregated because they interact to produce and perpetuate inequality and a variety of health disparities across the life span (Collins, 1990, 2000; Crenshaw, 1989; Dill & Zambrana, 2009; Schulz & Mullings, 2006; Warner & Brown, 2011). Chiefly, as it pertains to influenza vaccination, our findings provide strong evidence that not accounting for interacting social statuses masks the intensity and patterns of influenza vaccination disparities among jointly disadvantaged persons.

Regarding the additive model masking intensity of disparities, we found Hispanic men without a four-year college degree were roughly *half* as likely to be vaccinated as non-Hispanic Whites of *any* sex or educational attainment in the intersectionality model. The additive model, by comparison, found no significant racial/ethnic, sex or education disparities when they were considered alone. In fact, Hispanic men experienced significantly worse disparities in more than one interaction term combination, isolating them as a particularly vulnerable group not identified in the additive model. Language barriers (Pearson, Zhao, & Ford, 2011) and beliefs that influenza vaccination is unnecessary or ineffective (Cohen et al., 2012) have been cited as reasons why Hispanics may not vaccinate elsewhere in the literature.

Regarding the additive model masking patterns of interaction between race/ethnicity, sex, and education that may be behind influenza vaccination disparities, we found two significant moderating patterns. First, race/ethnicity moderates the relationship between sex and vaccination. This moderation was driven largely by Hispanic respondents, who had a large sex gap in influenza vaccination uptake that did not appear in other races/ethnicities. In fact, the gap was so large that while Hispanic males had the lowest predicted probability among all racial/ethnic-sex subgroups, Hispanic females had the highest. Wooten, Wortley, Singleton, & Euler (2012) found that minorities with low educational attainment had lower influenza vaccination uptake even when they had positive attitudes about vaccination. Clearly, we need further research understanding differences in vaccine uptake factors between Hispanic males and females to better understand how to mitigate persistent disparities in influenza vaccination. Last, we observed significant triple interaction. Only among non-Hispanic Whites did both sexes have higher vaccination uptake in with compared to without a four-year college degree. This raises a larger point suggesting that something about the attainment of college education may be different in minorities and may contribute to disparities in influenza vaccination (and perhaps other health and health services outcomes, as well). Indeed, studies examining the education gradient and health have found that the returns of higher education may differ by race/ethnicity, particularly with regards to health behavior (Williams & Collins, 1995). For instance, Perna (2005) found that post-secondary education increased the likelihood of having health insurance coverage more for blacks than for whites, but found no differences in other health behaviors by race. Previous research and the findings from the current analysis warrant additional research in the relationship between education and specific health behaviors and how it differs by race.

Closing thoughts

The health disparities research community has tended to focus mostly on racial/ethnic disparities in influenza vaccination, seldom focusing explicitly on such disparities by measures of SES or gender/sex. Further, it typically has treated race/ethnicity, gender/sex, and measures of SES as separate health determinants, which is a criticism of the field that intersectionality theory posits potentially obscures important differences in health and undermines efforts to reduce health disparities (Warner & Brown, 2011). There has been a plethora of research specifically examining disparities in influenza vaccination, though this literature suffers from the same criticism – to our knowledge, nothing is known about the synergistic effects of holding *multiple* such statuses. The findings from this study address this gap of knowledge as well as to contribute to the literature on intersectionality theory. They represent strong evidence for the use of hierarchical, multiplicative interaction of race/ethnicity, sex, and education in the specific context of influenza vaccine disparities in chronically-ill US adults, but also likely more broadly in the general context of health disparities in the United States. Simply examining these dimensions separately or in an additive fashion is not only fundamentally flawed, but underestimates the magnitude of, and masks the distinct patterns of, health disparities.

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Tables and Figures

Table 1

Characteristics of the analytic sample (N=7,936)

Variable	%	(n)
Influenza vaccination (prev. 12 months)		
Unvaccinated	43.0	(2,855)
Vaccinated	57.0	(5,059)
Race/ethnicity		
Non-Hisp. White	85.1	(5,441)
Non-Hisp. Black or African American	10.8	(2,048)
Any Hispanic	4.1	(447)
Sex		
Male	41.1	(2,492)
Female	58.9	(5,443)
Attained 4-year college degree		
No	77.1	(5,525)
Yes	22.7	(2,394)
Age (years)		
18-64	71.9	(4,722)
65 and older	28.1	(3,174)
Employment status		
Full-time (30+ hours/week)	32.6	(1,919)
Part-time (<30 hours/week)	14.1	(734)
Retired	26.3	(3,260)
Other	27.0	(2,004)
Household income (relative to Federal Poverty Line [FPL])		
Below FPL	28.5	(2,202)
Above FPL	71.5	(5,422)
Insurance status		
Currently uninsured	10.9	(662)
Currently insured	89.1	(7,268)
Smoking status		
Currently smokes	20.1	(1,291)
Does not currently smoke	79.9	(6,634)
Perceived discrimination in healthcare by race/ethnicity		
No	95.1	(7,291)
Yes	4.9	(577)
Perceived discrimination in healthcare by sex		
No	92.9	(7,168)
Yes	7.1	(661)
Variable	**Mean**	**(sd)**
Patient Activation Measure stage (1-4, 4 is most activated)	3.19	(0.842)
Health practices index (0-2, 0 is worst on diet, exercise)	1.23	(0.733)
Patient-provider relationship quality index (0-6, 0 is worst on respect, communication, time)	4.34	(1.540)
Trust in information from doctor (1-3, 1 is a lot, 2 is a little, 3 is not at all)	1.28	(0.505)
Self-rated health (1-5, 5 is excellent)	3.01	(0.972)
Number of chronic diseases (0-5)	1.41	(0.877)
Number of visits to healthcare providers to treat conditions (prev. 3 months; 0, 1, 2, 3, 4+)	1.11	(1.337)
Rating of all care received from all healthcare professional (prev. 12 months; 0-10, 10 is best possible)	8.20	(1.851)

Note: Due to missing values and/or rounding, the numbers in some of the cross-tabulations in this table may not add up to the total sample size. Sample sizes are unweighted to show actual number of respondents in each variable, though percentages and means are weighted to be representative of chronically-ill US adults in survey markets (a diverse set of healthcare markets that represent roughly one eighth of the US population).

Table 2

Correlates of influenza vaccination in the analytic sample (N=7,936)

Variable	Unvaccinated %	Vaccinated %	*p* value
Race/ethnicity			
Non-Hisp. White	41.4	58.6	
Non-Hisp. Black or African American	52.1	47.9	0.032
Any Hispanic	42.2	47.9	
Sex			
Male	43.2	56.8	
Female	42.8	57.2	0.878
Attained 4-year college degree			
No	45.2	54.9	
Yes	35.6	64.4	0.001
Age (years)			
18-64	50.2	49.8	
65 and older	24.5	75.5	<0.001
Employment status			
Full-time	45.8	54.2	
Part-time	43.4	56.7	
Retired	26.1	73.9	<0.001
Other	55.8	44.2	
Household income			
Below FPL	52.6	47.5	
Above FPL	38.9	61.2	<0.001
Insurance status			
Currently uninsured	72.8	27.2	
Currently insured	39.3	60.7	<0.001
Smoking status			
Currently smokes	58.7	41.3	
Does not currently smoke	39.1	61.0	<0.001
Perceived discrimination in healthcare by race/ethnicity			
No	42.2	57.8	
Yes	54.8	45.2	0.016
Perceived discrimination in healthcare by sex			
No	43.0	57.0	
Yes	39.7	60.3	0.437
	Unvaccinated mean (se)	Vaccinated mean (se)	*p* value
Patient Activation Measure stage	3.16 (0.040)	3.22 (0.028)	0.186
Health practices index	1.16 (0.034)	1.27 (0.024)	0.008
Patient-provider relationship quality index	4.22 (0.077)	4.43 (0.054)	0.027
Trust in information from doctor	1.29 (0.022)	1.26 (0.016)	0.287
Self-rated health	3.01 (0.050)	3.01 (0.034)	0.935
Number of chronic diseases	1.32 (0.037)	1.48 (0.029)	<0.001
Number of visits to healthcare providers to treat conditions	1.02 (0.056)	1.18 (0.044)	0.020
Rating of all care received from all healthcare professional	7.92 (0.101)	8.40 (0.062)	<0.001

Note: Due to missing values and/or rounding, the numbers in some of the cross-tabulations in this table may not add up to the total sample size. Percentages and means are weighted to be representative of chronically-ill US adults in survey markets (a diverse set of healthcare markets that represent roughly one eighth of the US population).

Table 3 Linear probability model (LPM) regression of influenza vaccination on its determinants (complete case analytic sample N=7,176)

	Model 1		Model 2	
Variable	β	95% CI	β	95% CI
Race/ethnicity (ref: non-Hisp. White)				
Non-Hisp. Black or African American	-0.005	-0.093, 0.083	-0.014	-0.187, 0.159
Any Hispanic	-0.010	-0.193, 0.173	***-0.266	-0.416, -0.117
Female	0.026	-0.028, 0.080	-0.009	-0.070, 0.061
Attained 4-year college degree	† 0.053	-0.004, 0.111	0.016	-0.074, 0.105
Race/ethnicity*female (ref: non-Hisp. White female)				
Non-Hisp. Black or African American female	--	--	0.036	-0.167, 0.238
Any Hispanic female	--	--	** 0.401	0.107, 0.696
Race/ethnicity*college degree (ref: non-Hisp White college)				
Non-Hisp. Black or African American with college degree	--	--	-0.100	-0.378, 0.179
Any Hispanic with college degree	--	--	0.164	-0.122, 0.450
Female*college	--	--	0.084	-0.029, 0.197
Race/ethnicity*female*college (ref: non-Hisp. White F college)				
Non-Hisp. Black or African American, female, college	--	--	-0.050	-0.388, 0.288
Any Hispanic, female, college	--	--	-0.332	-0.843, 0.178
65 and older	*** 0.159	0.094, 0.224	*** 0.160	0.095, 0.226
Employment status (ref: full-time)				
Part-time	0.025	-0.071, 0.121	0.025	-0.069, 0.120
Retired	0.025	-0.049, 0.100	0.026	-0.048, 0.101
Other	*-0.083	-0.163, -0.002	*-0.082	-0.161, -0.002
Household income above FPL	0.047	-0.027, 0.121	0.052	-0.022, 0.125
Currently insured	*** 0.204	0.108, 0.300	*** 0.222	0.131, 0.313
Does not currently smoke	* 0.095	0.020, 0.171	* 0.090	0.015, 0.165
Perceived discrimination in healthcare by race/ethnicity	-0.035	-0.160, 0.089	-0.021	-0.144, 0.102
Perceived discrimination in healthcare by sex	† 0.075	-0.008, 0.157	† 0.082	-0.002, 0.165
Patient Activation Measure stage	-0.001	-0.037, 0.036	0.001	-0.036, 0.037
Health practices index	* 0.043	0.006, 0.081	* 0.040	-0.220, -0.046
Patient-provider relationship quality index	0.000	-0.022, 0.022	0.000	-0.022, 0.022
Trust in information from doctor	-0.029	-0.082, 0.024	-0.025	-0.077, 0.028
Self-rated health	-0.024	-0.057, 0.009	-0.022	-0.055, 0.010
Number of chronic diseases	* 0.038	0.008, 0.068	* 0.040	0.010, 0.070
Number of visits to healthcare providers to treat conditions	* 0.022	0.001, 0.042	* 0.021	0.001, 0.042
Rating of all care received from all healthcare professional	0.012	-0.007, 0.031	0.013	-0.006, 0.032

Note: Also controls for survey market. Coefficients weighted to be representative of chronically-ill US adults in survey markets (a diverse set of healthcare markets that represent roughly one eighth of the US population); standard errors are adjusted for complex survey design and heteroskedasticity. †0.10>p≥0.05 *p<0.05, **p<0.01, ***p<0.001

Table 4

Predicted probabilities of influenza vaccination among interaction term subgroups from the complete case analytic sample (n=7,176)

Intersectional groups	Predicted probability (se)	95% CI
"One-way" interaction terms		
Race/ethnicity		
Non-Hispanic White	0.585 (0.015)	0.556, 0.614
Non-Hispanic Black or African American	0.561 (0.039)	0.484, 0.638
Any Hispanic	0.551 (0.070)	0.415, 0.688
Sex		
Male	0.568 (0.021)	0.526, 0.610
Female	0.597 (0.017)	0.564, 0.630
Education		
Did not attain a four-year college degree	0.572 (0.017)	0.539, 0.604
Attained a four-year college degree	0.621 (0.022)	0.577, 0.664
Two-way interaction terms		
Race/ethnicity*Sex		
Non-Hispanic White male	0.580 (0.023)	0.534, 0.626
Non-Hispanic White female	0.592 (0.018)	0.556, 0.628
Non-Hispanic Black or African American male	0.541 (0.069)	0.406, 0.676
Non-Hispanic Black or African American female	0.576 (0.044)	0.489, 0.663
Any Hispanic male	0.355 (0.061)	0.235, 0.475
Any Hispanic female	0.685 (0.108)	0.474, 0.896
Race/ethnicity*Education		
Non-Hispanic White without a four-year college degree	0.571 (0.018)	0.536, 0.606
Non-Hispanic White with a four-year college degree	0.635 (0.024)	0.588, 0.682
Non-Hispanic Black or African American without a four-year college degree	0.577 (0.048)	0.484, 0.671
Non-Hispanic Black or African American with a four-year college degree	0.513 (0.064)	0.388, 0.639
Any Hispanic without a four-year college degree	0.536 (0.083)	0.373, 0.699
Any Hispanic with a four-year college degree	0.573 (0.112)	0.354, 0.791
Sex*Education		
Male without a four-year college degree	0.564 (0.026)	0.513, 0.615
Male with a four-year college degree	0.577 (0.034)	0.510, 0.643
Female without a four-year college degree	0.574 (0.021)	0.534, 0.615
Female with a four-year college degree	0.653 (0.028)	0.598, 0.708
Three-way interaction term		
Race/ethnicity*Sex*Education		
Non-Hispanic White male without a four-year college degree	0.576 (0.028)	0.521, 0.632
Non-Hispanic White male with a four-year college degree	0.592 (0.037)	0.520, 0.663
Non-Hispanic White female without a four-year college degree	0.567 (0.022)	0.523, 0.611
Non-Hispanic White female with a four-year college degree	0.667 (0.030)	0.608, 0.726
Non-Hispanic Black or African American male without a four-year college degree	0.562 (0.084)	0.398, 0.727
Non-Hispanic Black or African American male with a four-year college degree	0.478 (0.108)	0.266, 0.691
Non-Hispanic Black or African American female without a four-year college degree	0.589 (0.053)	0.485, 0.692
Non-Hispanic Black or African American female with a four-year college degree	0.539 (0.076)	0.390, 0.688
Any Hispanic male without a four-year college degree	0.310 (0.071)	0.171, 0.449
Any Hispanic male with a four-year college degree	0.490 (0.120)	0.253, 0.726
Any Hispanic female without a four-year college degree	0.702 (0.132)	0.444, 0.960
Any Hispanic female with a four-year college degree	0.633 (0.172)	0.297, 0.970

Note: We used Stata margins commands to calculating predicted linear probabilities of influenza vaccination among all hierarchical interaction term subgroups from the full regression model (Model 2 of Table 3). These predicted probabilities incorporate mean values for all other determinants and survey market, and are weighted to be representative of chronically-ill US adults in survey markets (a diverse set of healthcare markets that represent roughly one eighth of the US population). Standard errors were calculated using the delta method.

Figure 1

Predicted probability of influenza vaccination among two-term interaction subgroups

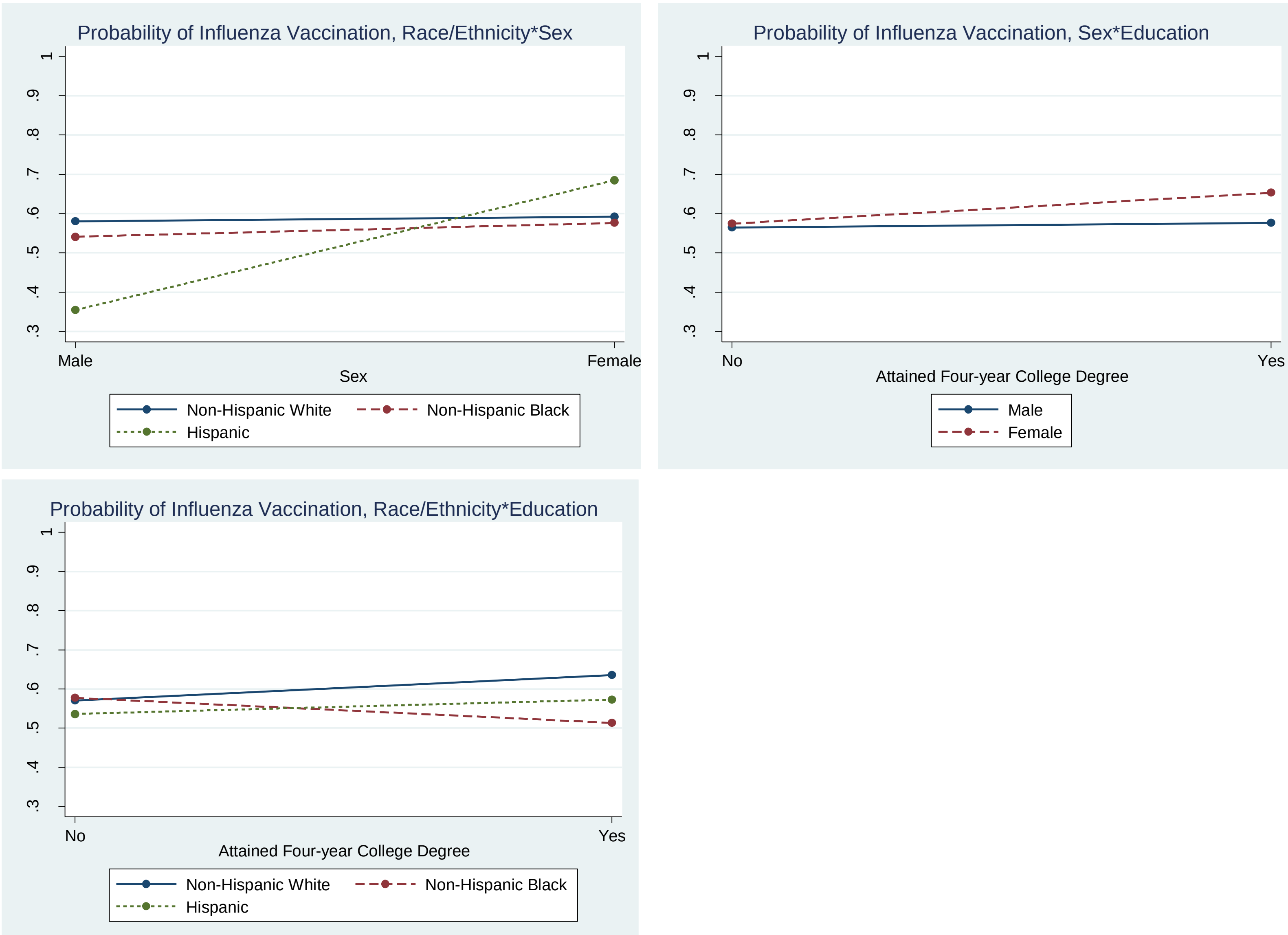
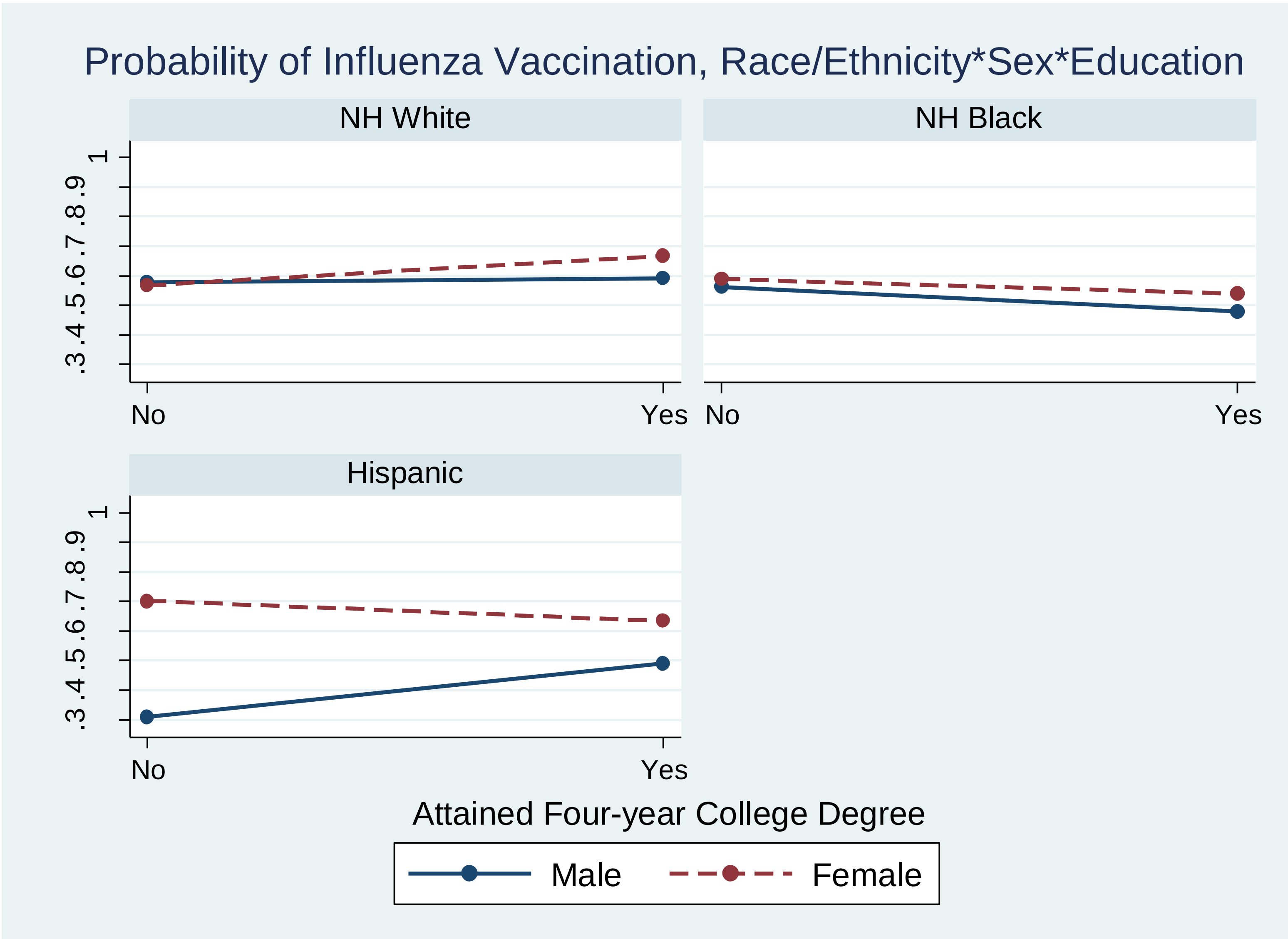


Figure 2

Predicted probability of influenza vaccination among three-way interaction subgroups



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