ABSTRACT

Title of Thesis: H1N1 RISK AND VULNERABILITY: APPLYING INTERSECTIONALITY IN A PANDEMIC CONTEXT

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During influenza pandemics, existing health disparities are exacerbated, increasing vulnerability to disease among minority populations. This research utilized national survey data collected during 2009-10 H1N1 Influenza pandemic to examine the relationship between vulnerability and perceived H1N1 risk in a sample (N=1,479) of non-Hispanic White, non-Hispanic Black, and Hispanic adults and the prospective association of vulnerability and perceived H1N1 risk on vaccine uptake seven months later (N=913). Bivariate analysis and linear regression modeling were used to detect patterns in perceived H1N1 risk. Logistic regression modeling was used to test independent variables on vaccine uptake. Hispanics and non-Hispanic Blacks had higher vulnerability compared to non-Hispanic Whites. Race/ethnicity and vulnerability were significant independent predictors for perceived H1N1 risk. We observed a positive, graded relationship between odds of vaccination and perceived H1N1 risk.

H1N1 RISK AND VULNEARBILITY: APPLYING INTERSECTIONALITY IN A PANDEMIC CONTEXT

by

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Dedication

Zach Gieske, thank you.

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List of Abbreviations

ABS – Address-Based Sampling

ACIP – Advisory Committee on Immunization Practice

CDC – Centers for Disease Control and Prevention

CPS – Current Population Survey from the U.S. Census

FDA – Food and Drug Administration

FPL – Federal Poverty Level

ILI – Influenza-like Illness

KN – Knowledge Networks

RDD – Random Digit Dialing

WHO – World Health Organization

Chapter 1: Introduction & Specific Aims

Overview

Pandemic influenza poses a significant threat to the public health of the nation. However, this threat is not equally distributed across the population. Evidence suggests that social inequality increases vulnerability to influenza[1, 2]. Social inequality may also translate into greater perception of disease risk [3]. Utilizing data from the 2009-10 H1N1 influenza pandemic, we explored the effect of social inequality related to sex and race/ethnicity during a pandemic in three areas: vulnerability to H1N1, perceived H1N1 risk, and H1N1 vaccine uptake.

Background

2009-2010 H1N1 Influenza Pandemic

In early 2009, public health officials identified a novel strain of swine influenza in Mexico [4]. The first confirmed case of "swine flu" in the United States was reported that April [5]. The disease spread quickly and less than a month later the Centers for Disease Control and Prevention (CDC) had declared a national public health emergency [4]. On June 11th, the World Health Organization (WHO) declared a worldwide pandemic at the highest alert level [6]. A novel strain of Influenza Type A (H1N1) was identified and became the fourth influenza pandemic to sweep the globe in one hundred years. The virus was very contagious with an estimated population-wide attack rate of 24%, but had a relatively low mortality rate of about 0.2% (comparable to seasonal influenza)[7]. With little natural immunity, a large proportion of the population became infected, with an unusually high severity and mortality among children and young adults [8, 9].

In September of 2009, the Food and Drug Administration (FDA) approved a monovalent vaccine specific to the novel A(H1N1) strain and released limited quantities to the public [4]. Since the novel strain emerged after production of the annual trivalent seasonal influenza vaccine was underway, the seasonal influenza vaccine that was released earlier in the year did not include the novel H1N1 strain and was not expected to be effective[10]. Anticipating vaccine shortages, the American Committee for Immunization Practices (ACIP) established "priority-groups" for early vaccination in October, with widespread vaccination occurring nationwide by December [11]. Despite an expensive and high-profile vaccination campaign from the CDC, vaccine uptake was distressingly low, with roughly 27% percent of eligible individuals (>6 months) receiving the vaccine [10]. Disparities in vaccine uptake were observed between racial groups; only 22% of non-Hispanic Blacks report vaccination compared to 27% of non-Hispanic Whites and 28% of Hispanics [12].

At the conclusion of the pandemic in April of 2010, an estimated 60 million cases, 275,000 hospitalizations, and 12,500 deaths were attributed to the H1N1 virus nationally [8]. Follow up studies confirmed that although infection rates were similar across racial/ethnic groups, reports indicate a disparity in severe outcomes, with minority groups reporting disproportionately high rates of hospitalization, flu-related complications and pediatric mortality [13-15]. In this post-pandemic period, as global health agencies prepare for the next novel influenza strain, it is important for researchers to learn from the 2009 H1N1 pandemic.

Specific Aims & Hypotheses

The purpose of this study was to build upon existing research on the role of social inequality during the H1N1 influenza pandemic. This study was also designed to explore new approaches to health risk research by engaging with intersectional theories and methodologies.

The five specific aims of this study were:

1. To describe distribution of vulnerability to H1N1 by sex and race/ethnicity.
2. To describe the distribution of perceived H1N1 risk by sex, race/ethnicity, and vulnerability.
3. To examine whether sex, race/ethnicity and vulnerability are predictors of perceived H1N1 risk.
4. To examine whether vulnerability accounts for the associations between sex and race/ethnicity with perceived H1N1 risk.
5. To examine whether sex, race/ethnicity, vulnerability, and perceived H1N1 risk were significant independent predictors of H1N1 vaccine uptake.

We hypothesize that social inequality related to sex and race/ethnicity will contribute to greater vulnerability to H1N1 among women and non-White minority groups. We also hypothesize that sex, race/ethnicity, and vulnerability will be significant independent predictors of perceived H1N1 risk. We predict that perceived H1N1 risk will be greater among women when compared to men, and among non-White populations when compared to non-Hispanic Whites. We also predict positive relationship between vulnerability and perceived H1N1 risk. Finally, we expect to see significant relationships between sex, race/ethnicity, vulnerability, and perceived H1N1 risk and vaccine uptake.

Chapter 2: Literature Review

Existing Knowledge

Disparities in Influenza Risk

Scholars have long understood that during a pandemic, disease risks are unequally distributed. Quite often, populations that are already disadvantaged are at greatest risk for disease, further exacerbating existing social inequalities. Recent efforts have attempted to quantify this relationship between inequality, social disadvantage, and vulnerability to influenza. Major influenza pandemics have occurred semi-regularly, with four major pandemic events occurring in the past one hundred years; including the 1918 Spanish Flu, the 1957 Asian Flu, the 1968 Hong Kong Influenza, and the most recent 2009 H1N1 Pandemic [16]. While each of these pandemics were unique, the old axiom that "the flu hit the rich and the poor alike" did not hold true [17]. There is evidence that in previous outbreaks, economically and socially disadvantaged populations shouldered a disproportionate burden of disease mortality, adverse health incomes, and negative economic impacts [18].

In 2008, as part of pandemic preparedness efforts, the CDC spearheaded research to understand potential sources of disparity in influenza risk. This research resulted in a conceptual framework to predict the sources of health disparities at three levels; 1) differential exposure to the virus; 2) differential susceptibility to disease, if exposed; and 3) differential access to timely and appropriate treatment, if infected [1]. This model proposes that disparities at multiple levels interact "synergistically" to produce unequal levels of influenza-related morbidity and mortality.

At the start of the H1N1 pandemic, Quinn et al. conducted independent research and were able to operationalize and test this conceptual model with data from their national surveys [2]. Expanding upon Blumenshine's original model, they assessed disparities in exposure, susceptibility, and access using additive indices as well as incorporating an additional measure of discrimination. Since influenza transmission is primarily airborne, disparities in exposure are often associated with greater social interaction and crowding [1]. The intersection between crowding and social position is manifested in multiple ways, and Blumenshine highlights crowded living conditions, reliance on public transportation, overwhelmed emergency medical clinics, and occupational policies as potential sources of exposure [1]. Quinn et al. confirmed these findings, demonstrating that minority populations faced greater chance of exposure from crowded housing and workplace policies that reduced ability to engage in social distancing practices [2]. Underlying health conditions can modify susceptibility to influenza. Those who live with chronic conditions or immunodeficiency are more likely to contract the disease, if exposed, and are also more likely to suffer from severe health impacts or complications if infected [1]. Again, Quinn et al. confirmed differential levels of susceptibility across racial groups, with substantially increased risk due to chronic disease among the non-Hispanic Black population [2].

Finally, although most cases of influenza do not often require treatment beyond supportive care, there is growing evidence that access to timely and effective medical care can reduce the length and severity of disease and any influenza-related complications [1]. Differential access to healthcare resources was documented by Quinn et al., with a significant proportion of the Hispanic population without a regular healthcare provider and/or lacking in health insurance [2]. Quinn et al. also argued that experiences of discrimination further alienate members of minority groups from the healthcare system and predispose individuals to mistrust healthcare professionals [2]. This research confirmed that existing disparities related to exposure, susceptibility, access and discrimination created elevated vulnerability for disease among racial/ethnic minority groups during the H1N1 pandemic.

Follow-up research by Kumar et al. confirmed that these disparities, particularly related to work-related exposures and social-distancing practices contributed to differential burdens of disease, as measured by self-reported ILI-symptoms (Influenza-like Illness: defined as fever, shivering, chills, dry cough, body aches, and/or malaise)[15]. Due to the nature of influenza infection, small increases in vulnerability can translate into an exponential increase in the burden of disease[15].

Perceived Risk and Vaccination

In additional to vulnerability to infection, the perception of disease risk also plays an important role in health decisions. Risk perception is a construct frequently utilized in health behavior theories to measure an individual's understanding of the likelihood and severity of a health threat. To assess risk perception related to vaccine preventable illness, researchers typically measure both an individual's perceived likelihood of contracting a vaccine preventable illness and an individual's perceived severity of that illness [19]. To measure accurately, risk perception questions need to be conditioned on not taking action, or in this instance, not getting vaccinated [19].

In these health behavior theories, the general assumption is that a high level of perceived risk should compel individuals to take actions to reduce their risk, such as getting vaccinated [20]. Meta-analysis on the association between perceived disease risk and vaccination are generally positive, but the effect sizes are quite weak, perhaps due to methodological errors [19]. While perceived risk is one of many possible predictors for vaccination, it has been found to be a significant predictor for uptake of H1N1 vaccine among a diverse sample of American adults [21].

Social Inequality, the 'White Male Effect', and Perceived Risk

Social psychologists have repeatedly observed patterning in perception of risk by sex and race. Research by Flynn et al. was one of the first to document that across a wide range of potential hazards, white men perceive far fewer risks when compared to women and members of minority groups [22]. This "White Male Effect" (WME) has fascinated risk researchers for decades as they attempt to explain the factors driving this phenomenon, with most recent scholarship concluding that sociopolitical factors have the most significant role [23]. Finucane argues that, "The world seems safer and hazardous activities seem more beneficial to white males than to other groups… Compared with white males, many females and nonwhite males tend to be in positions of less power and control, benefit less from many technologies and institutions, are more vulnerable to discrimination, and therefore see the world as more dangerous" [23](p. 170).

Further research on the role of sociopolitical factors was conducted by Satterfield, Mertz & Slovic, by modeling the subjective experience of vulnerability, discrimination, and justice on the level of perceived risk [24]. They confirmed the existence of the WME, but found in addition to demographic differences, social vulnerability and feelings of injustice were also significant predictors for perceived risk [24]. A similar study of risk perception exclusively within the African American community confirmed that greater social and political power correlates with lower perception of risk [25].

Even greater evidence to support the role of sociopolitical factors comes from Sweden, where researchers decided to test for the WME among the much more egalitarian Swedish society. The results of this study revealed very little difference in perceived risk across males and females, but highlighted greater differences between native-born Swedes and non-native immigrant groups [3]. Interpreting this evidence, the researchers conclude that “White Male Effect” may be a misnomer, what is actually being observed might better be described as a “Social Inequality Effect” with greater social vulnerability translating into greater perception of risks [3]. The argued that an emphasis on social inequality or “vulnerability” which they defined as “the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist or recover from the impact of a hazard” allowed for a more nuanced understanding of the heterogeneity within groups [26].

Intersectionality in Risk Research

Intersectionality, as a concept, emerged in the late 1980’s with the work of feminist legal scholar, Kimberle Crenshaw. In her essay, *Mapping the Margins*, she outlines how the dual influences of both race and sex function together to creating “multiple marginalizations” that structure the everyday experiences of women of color [27]. The concept is deeply influenced by critical race studies and has historically focused on the intersectional impact of racism and sexism [28]. The growing area of Public Health Critical Race Praxis has embraced this approach and applied it to the field of health equity research to explore the impact of social inequality in racial/ethnic health disparities

[29, 30]. The focus of this work is on race and sex as social constructs, and the impact of racism and sexism on health [31].

In the field of health-risk research, scholars have been slower to embrace intersectional approaches, partially due to the difficulty of adapting intersectional approaches to quantitative methodologies [32]. Typically quantitative approaches to intersectionality have focused on multiplicative effects or on detecting interactions between variables[28, 33]. Despite these challenges, several scholars have successfully demonstrated the effectiveness of quantitative intersectional approaches to elucidate the heterogeneity within minority groups that contribute to differential health outcomes [34, 35].

Gaps in knowledge

Until now, each of these research areas has been considered separately. Research by Quinn et al. and others has started to confirm the association between social inequality and disparities during pandemic influenza [2, 15, 36]. However, the body of empirical evidence to support the role of vulnerability during influenza pandemics is still quite small and quite often is focused on the famous 1918 "Spanish" Influenza. More evidence is needed to fully characterize and recognize the scope of disparities in risk during modern influenza pandemics.

This will also be the first application of the "White Male Effect"/ "Social Inequality Effect" in vaccine research. Risk researchers tend to engage with these effects on a theoretical level and very few studies have attempted to engage with them in an applied context. While race/ethnicity, sex, and aspects of vulnerability are common covariates in vaccine research they are not viewed in the context of this effect.

Finally, the body of research on vaccine disparities fails to engage with concepts of social inequality. Research may engage with existing disparities on a single level such as race/ethnicity, or sex, or SES, or education level, or barriers to access, but few are focusing on the ways these multiple levels of social disadvantage intersect.

Chapter 3: Research Design and Methods

Study Design

We conducted secondary analysis of national survey data, using two-waves of a survey collected by Quinn et al. at during the H1N1 influenza pandemic. The data was collected as part of an emergency preparedness research project and funded through the CDC (Grant No. 1P01TP000304-01). The original purpose of the data was to survey people's opinions and perceptions of the H1N1 outbreak with emphasis on respondents' knowledge of H1N1 influenza and their willingness to take protective actions recommended by government officials, including the use of drugs or vaccines.

Data Source

Both surveys were conducted through the Knowledge Networks (KN) online research panel. The KN panel utilizes probability-based sampling, combining both address-based sampling (ABS) and random-digit dialing (RDD) methods to create overlapping sampling frames that cover an estimated 99% of the US population[37]. To reach Hispanic populations, KN also utilizes an additional KnoweldgePanel Latino, which oversamples geographic regions with relatively large Hispanic populations and offers surveys in both English and Spanish. KN pre-tested both surveys for accuracy. To ensure that both low-income and offline populations are adequately represented, KN provides computer hardware and Internet access as needed.

For client surveys, KN randomly selects research participants from active panel members. Selected panelists are invited to participate via email. After three days, automatic email reminders are sent to all non-responding panelists in the sample. After six days a phone call is made to remind panelists to complete the survey. Panelists receive a small incentive in the form of points redeemable for cash in return for completed surveys.

Study Population

The data used in this survey was collected at two points during the H1N1 pandemic. The baseline survey was conducted in June of 2009 with a follow up survey seven months later in January of 2010. For the initial baseline survey, a random sample of 2,498 adults, including intentional oversampling of Black and Hispanic adults, were invited to participate. A total of 1,543 adults completed the survey for a completion rate of 62%. Analysis was restricted to the 1,479 individuals who identified as either non-Hispanic White, non-Hispanic Black, or Hispanic.

1,326 respondents from the baseline survey were invited to participate in the follow up survey. Of this group, 71% completed the survey, for a longitudinal sample of 939. As in the baseline survey, analysis was restricted to the 913 individuals who identified as either non-Hispanic White, non-Hispanic Black, or Hispanic. In both surveys, individuals who selected “Other” or “2 or more races” for race/ethnicity were excluded from analysis due to small sample size and extreme heterogeneity within group.

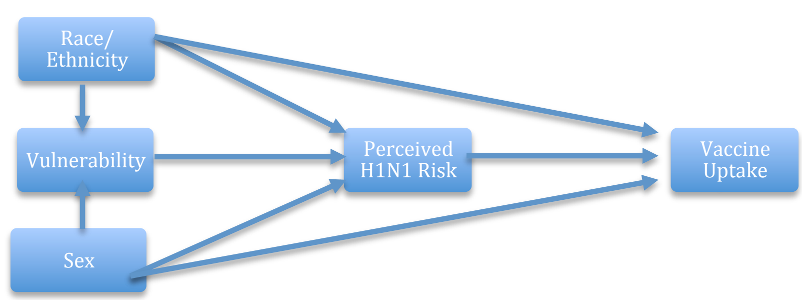
Description of Variables

Independent and Dependent Variables

Figure 1 outlines the hypothesized relationship between the variables. For Aim 1, race/ethnicity and sex serve as independent variables with vulnerability as the dependent variable. For Aims 2, 3, and 4, race/ethnicity, sex, and vulnerability serve as independent variables with perceived H1N1 risk as the dependent variable. In Aim 5, race/ethnicity, sex, vulnerability and perceived H1N1 risk all serve as independent variables with vaccine uptake as the dependent variable.

This research utilized variables from both surveys. Items from the baseline survey included: sex, race/ethnicity, age, vulnerability, and perceived H1N1 risk. The only variable from the follow up survey was vaccine uptake. Additionally, KN maintains separate data files of demographic information about all panelists and provided this information as a set of supplemental variables.

Figure 1. Hypothesized Relationship Between Variables



Sex

Individuals were asked a single item for sex. Responses for sex were self-report and limited to male or female. Sex was utilized as an independent variable.

Race/Ethnicity

Racial/ethnic categories were assigned using two items: race/ethnicity and language of survey. The first item was self-report of race/ethnicity. Individuals were given the following options: non-Hispanic White, non-Hispanic Black, 2-or more races, Hispanic, or Other. Only participants that selected non-Hispanic White, non-Hispanic Black, or Hispanic were included in analysis. A second item reported language of the survey as English or Spanish. Only KnowledgeLatino panelists had the option to take the survey in Spanish. The overall Hispanic subsample was further divided into English-speaking Hispanic and Spanish-speaking Hispanic. Race/ethnicity was utilized as an independent variable.

Age

Age was assessed as a continuous variable, measured in years. Age was utilized as a covariate in Aims 3-5.

Vulnerability to H1N1 Index

In order to capture vulnerability to H1N1 in a single measure, we created an additive index of vulnerability by combining elements of exposure, susceptibility, and access with measures of structural inequality. Using items from the baseline survey, these nine index components include:

1. Living in poverty
2. Having less than a high school education
3. Children in household
4. Crowded living conditions
5. Work-related policies
6. Social distancing practices
7. Poor health
8. Barriers to health care access
9. Discrimination in health care

Items 3, 4, 5, 6, 7, 8 and 9 were adapted from additive indices done by Quinn et al. [2]. Items 1 and 2 were added to capture generalized vulnerability related to relative social position. We created a score based on the sum of these nine components. A single survey item was used to assess items 1, 2, 3, and 9. Items 4, 5, 6, and 7 relied on information from more than one item. In these instances, a total score was derived and a threshold was used to dichotomize answers. All nine components were coded dichotomously, with a score of either 0, indicating low vulnerability, or a score of 1, indicating high vulnerability.

Living in Poverty

Poverty status was determined with an income-to-household size ratio. This ratio was calculated for each respondent and compared against Federal Poverty Guidelines for 2009 [38]. Living in poverty was defined as <100% federal poverty level (FPL). We used this information to create a new dichotomous variable "Poverty" and assigned a score of 1 to individuals living in poverty.

Having less than a High School Education

We measured education with a categorical variable of highest degree completed. Individuals who had not completed high school or an equivalent (GED) were considered as having less than a high school education. We created a new dichotomous variable "< H.S. Education" and assigned a score of 1 to individuals with less than a high school education.

Children in Household

We relied on several variables that measured household composition to determine the presence of children in an individual's household. These included; the presence of children 0-2, presence of children 2-5, presence of children 6-12, and the presence of children 13-17. A new dichotomous variable "Children" was created to capture the presence of any children in the home, ages 0-17. Any household with a child age 0-17 was assigned a score of 1.

Work-Related Policies

This component was created to capture differential workplace exposure to influenza due to workplace policies that limited an individual's ability to stay home when sick. This single component combines responses to three items from the baseline survey. While the entire sample answered these three items, analyses were limited to adults who reported working outside of the home (n=764).

First, a question asked, "If public health officials declared that it was necessary for people to stay home from work and school how difficult would it be for you to stay home from work for 7-10 days?" Response categories were limited to a four-point Likert-scale ranging from "Very difficult" to "Not difficult at all". This item was recoded as "Stay home" and dichotomized so that "Very difficult" and "Somewhat difficult" equaled a score of 1 and any other response equaled 0.

Second, a multi-part survey item asked "Please indicate yes, no, or not applicable on each of the following items" with two relevant questions "If I did not go to work, I will not get paid for the time I am at home" and "I have sick leave at my job if I need to use it." The first was recoded as "Paid Leave" and dichotomized with an answer of "Yes" equal to 1. The second item was renamed as "Sick Leave", reverse coded and dichotomized with an answer of "No" equal to 1.

All three work-related items were then summed scores for "Stay home", "Paid Leave" and "Sick Leave" and any individual who scored more than 1 was given a score of 1 for new variable "Work-related policies".

Crowded Living Conditions

Living conditions were assessed using two demographic variables from the KN dataset. The first asked the number of adults >18 living in the house. This variable was recoded as "Crowding" and any response that was greater than 2 adults was given a score of 1. The second item measured housing type. A new variable "Apartment" was created. Individuals who lived in multi-unit housing were rescored with a 1 for "Apartment" and all other housing types were given a 0.

These two new items, "Crowding" and "Apartment" were combined in a new variable "Crowded Living Conditions". Any individual who had a combined score of 1 or more was given a score of 1 for a new variable.

Social Distancing Practices

Social distancing practices were assessed through two items from the baseline survey. The survey item asks, "If public health officials declared that it was necessary for people to stay home from work and school, how difficult would it be for you to…" with two different questions. First, "Have day care for your child that is not with a group of children, if schools were closed?". This item was only displayed to the 505 individuals who had indicated that they had children <18 living in their home. This item was recoded as "Daycare" and dichotomized so that adults who indicated "Very difficult" or "Somewhat difficult" were given a score of 1. Frequencies reflect the total number of parents who rely on public daycare out of the total sample of individuals with children in the home.

The second question asks, "Use private transportation to avoid crowds on public transportation." This item was recoded as "Transit" and dichotomized so that adults who indicated "Very difficult" or "Somewhat difficult" were given 1.

The two scores for "Daycare" and "Transit" were combined into a new item labeled "Social Distance" and then dichotomized. Any individual with a score of 1 or higher was assigned a score of 1 for "Social Distance".

Poor Health

This component was designed to capture a wide range of co-morbidities that could contribute to greater susceptibility for influenza infection. Two items from the baseline survey were utilized to capture poor health. The first asks, "Have you ever been told by a health professional that you have any of the following chronic diseases? Check all that apply." Response options include: a. Heart disease, b. High blood pressure, c. Cancer, d. Diabetes, e. Asthma, f. Lung diseases such as chronic pulmonary lung disease, g. other, h. none. This item was recoded as "Chronic disease" and a response of yes to one or more of these conditions (with the exception of h. none) was assigned a score of 1.

A second question asked, "Do you have any diagnosed health conditions or have you received any medical treatment that has weakened your body's ability to fight off disease?" with "Yes" or "No" response options. This item was recoded as "Immunodeficiency" and answers of "Yes" were recoded with a score of 1.

The two items, "Chronic condition" and "Immunodeficiency" were summed. The scores were dichotomized as a new variable "Poor health" and any individuals with a score greater than or equal to 1 were assigned a 1 for "Poor health."

Barriers to Health Care Access

Two survey items were used to capture barriers in access to health care. The first asked, “Do you have a regular health care provider?” with response options of “Yes” or “No”. A second item asks, “Do you have health insurance?” again with response options of “Yes” or “No”. Individuals who responded “No” to one or both of these items were reclassified with a score of 1 for a new variable of “Barriers”.

Discrimination in Health Care

A single survey item from the baseline survey captured this component. This item asked, “When you seek health care, have you ever experienced discrimination or been hassled or made to feel inferior because of your race, ethnicity, or color?” Response options included: “No/never”, “Once”, “Two-three times”, or “Four or more times”. Any individual who reported one or more experience of discrimination was reclassified with a score of 1 for a new variable of “Discrimination”.

Table 1. Vulnerability Index Components

Index Component	Original Variables New Component Variables New Final Variable	Scoring
Living in poverty	Variables for household size and household income were used to calculate a ratio. This ratio was compared to Federal Poverty Estimates for 2009. A new variable “Poverty” was created. Responses were dichotomized into above and below poverty.	< 100% FPL = 1
<H.S. Education	A variable for highest level of education was used. A new variable “<H.S. Education” was created. Responses were dichotomized into more than or less than a H.S. Education.	< H.S. = 1
Children in household	Several variables on household composition were combined. A new variable “children” was created. Any individual who reported 1 or more children <18 in their household were recoded with a score of 1.	≥ 1 child = 1
Crowded living conditions	Two new variables were created “Crowding” and “Apartment” based on demographic variables. An overall variable “Crowded Conditions” was created. If individuals reported a score of 1 for either “Crowding” or “Apartment” or both, a score of 1 was assigned for “Crowded conditions”	Total score ≥ 1 = 1
Work-related policies	Three new variables were created. “Stay Home” “Paid Leave” and “Sick Leave” all based on survey items. An overall variable “Work-related” was created. If individuals reported a score of 1 for any one or combination of the three variables “Stay Home” “Paid Leave” “Sick Leave” they were assigned a score of 1 for “Work-related”	Total score ≥ 1 = 1
Social distancing practices	Two new variables were created. “Daycare” and “Transit” based on survey items. An overall variable “Social Distance” was created. If individuals report a score of 1 for either “Daycare” or “Transit” or both, they were assigned a score of 1 for “Social Distance”.	Total score ≥ 1 = 1
Poor health	Two new variables were created “Chronic Binary” and “Immune” based on survey items. An overall variable “Poor Health” was created. If an individual reported a score of 1 for either “Chronic Binary” or “Immune” or both, a score of 1 was assigned for “Poor Health”.	Total score ≥ 1 = 1
Barriers to health care access	Two new variables were created “Access” and “Insurance” based on survey items. An overall variable “Barriers” was created. If an individual reported a score of 1 for either “Access” or “Insurance” or both, a score of 1 was assigned for “Barriers”	Total score ≥ 1 = 1
Discrimination in health care	A new variable “Discrimination was created based on a survey item. Individuals who reported any experiences of discrimination were given a score of 1.	≥ 1 experience of discrimination = 1

Perceived H1N1 Risk

The baseline survey includes 5 Likert-style items designed to assess perceived H1N1 risk, including measures on perceived susceptibility, perceived severity, and perceived consequences of disease on an individual and his/her family (Table 2).

Table 2. Perceived H1N1 Risk Items

How likely do you think it is that swine flu will affect your family, friends, and neighbors?			
Very Likely	Likely	Unlikely	Very Unlikely
How Likely are you to become ill with swine flu?			
Very Likely	Likely	Unlikely	Very Unlikely
If swine flu was or is in your community, how severe do you think the consequences might be to you and your family?			
Very Severe	Severe	Not at all Severe	
If a member of your immediate household became ill with swine flu, how likely do you believe it is that the person might die from it?			
Very Likely	Likely	Unlikely	Very Unlikely
How much do you agree or disagree with the following statement? I am not concerned about getting swine flu.			
Strongly Disagree	Disagree	Agree	Strongly Agree

An exploratory factor analysis (principal components extraction) conducted by Quinn et al. confirmed that all items loaded on a single factor, with Cronbach's alpha of 0.78 [39]. To recreate the factor, we reverse coded the item responses so that higher values reflect greater perceived H1N1 risk. Since the response categories were not consistent across all 5 items, all responses were standardized to a mean of 0 and a standard deviation of 1. Then a mean score was calculated for each respondent. After calculating the mean score, the results were standardized once again. Perceived H1N1 Risk was utilized as both an independent variable (Aim 5) and a dependent variable (Aims 2-4).

Vaccine Uptake

The follow up survey included a survey item to measure vaccine uptake for the H1N1 vaccine. The item asked, "Have you gotten the swine flu vaccine for yourself?" Responses were limited to "Yes" or "No". Self-report has been demonstrated to be a reliable measure of vaccine uptake for seasonal influenza vaccine and no studies have sought to validate self-report as a reliable measure for the H1N1 vaccine [40]. The seven month period between baseline and follow up surveys was critical to establish temporal relationship between the independent variables and vaccination behavior, and also to ensure that perceived H1N1 risk items were conditioned on not being vaccinated. Vaccine Uptake was utilized as a dependent variable (Aim 5).

Sample Weights

KN utilizes complex survey design methods and provides additional weighting variables for analysis (see Table 1). Statistical weighting adjustments are made to the data to offset known selection deviations and are incorporated into the base weight. However, several sources of survey error related to panelist recruitment and retention are inevitable, including non-response and panel attrition. KN also provides post-stratification weights to adjust for these sources of error. Both the baseline and the follow-up surveys include post-stratification weights to adjust demographic distributions benchmarked against the Current Population Survey (CPS) for May of 2009 and for Spanish language usage from the 2006 Pew Hispanic Center Survey[37].

In our analysis, the total Hispanic sample was weighted to be demographically representative of the national Hispanic population. However, we made the choice to subdivide this population into those who chose to take the survey in English and those who chose to take the survey in Spanish. With this design choice, the subpopulations of English-speaking Hispanic and Spanish-speaking Hispanic adults are no longer nationally representative.

Human Subjects

All survey data was de-identified by KN. All individuals were identified with a KN-provided case ID. The original study protocol and data collection methods were approved by the institutional review boards of the University of Pittsburgh (PRO09050129) and the University of Georgia (2009-10874-0). The aims and methods of the current secondary analysis were approved as exempt by the institutional review board at the University of Maryland, College Park (897380-1).

Data Analysis

We analyzed all data with SAS Studio (SAS Studio, Cary NC) using complex survey analysis procedures to account for sample design and weighting. All results were weighted to be nationally representative based on census estimates from 2009. For the longitudinal dataset, an additional survey weight was applied to make the longitudinal sample nationally representative.

For the first research aim, we created the variables for the vulnerability index and calculated vulnerability scores. We presented mean vulnerability scores by race/ethnicity and sex. We tested for disparities by sex using a two-sided t-test and for disparities by race/ethnicity with ANOVA. We also presented frequencies of each vulnerability component by race/ethnicity. Adjusted Pearson x^2 tests were utilized to detect significant differences by race/ethnicity. We also utilized adjusted Pearson x^2 to test for differences by sex and race/ethnicity with a categorical measure of vulnerability quartiles.

For the second, third, and fourth research aims we present distributions of perceived H1N1 risk. First we calculated scores for perceived H1N1 risk. Then we ran bivariate analyses using adjusted Pearson x^2 to compare categorical measures of perceived H1N1 risk quartiles by sex, race/ethnicity and vulnerability. Since we detected significant interaction effects between sex and race/ethnicity, further analysis on perceived H1N1 risk was stratified by sex. The relationship between race/ethnicity and vulnerability on perceived H1N1 risk was also examined using linear regression, adjusting for age and stratifying by sex. We also tested for interaction effects between sex and race/ethnicity, sex and vulnerability, and race/ethnicity and vulnerability.

Finally, we assessed the relationship between sex, race/ethnicity, vulnerability, and perceived risk on vaccine uptake using logistic regression, adjusting for age. All independent variables were assessed for interaction effects: sex and race/ethnicity, sex and vulnerability, sex and perceived H1N1 risk, race/ethnicity and vulnerability, race/ethnicity and perceived H1N1 risk, and vulnerability and perceived H1N1 risk. A p value of $< .05$ was used to indicate a significant finding**.**

Chapter 4: Results

Sample Description

Table 3 reports sample distributions for both the baseline and follow-up survey. The sample is nationally representative and the racial/ethnic distribution reflects national averages from 2009. In the baseline survey, 73% of the sample was non-Hispanic White (n=991), 12% non-Hispanic Black (n=194), and 14% Hispanic (N=294). Of the total Hispanic subpopulation, 77% took the survey in Spanish (n=229) and 33% took the survey in English (n=65).

Although the longitudinal sample is roughly 1/3 smaller than the baseline sample, a similar racial/ethnic distribution was observed. Seventy-two percent of the sample was non-Hispanic White (n=664), 12% was non-Hispanic Black (n=112), and 15% was Hispanic (n=137). Of the total Hispanic subpopulation in the longitudinal sample, 71% opted to take the survey in Spanish (n=98) and 39% took the survey in English (n=39).

The distribution of sex and age in both surveys reflects the distributions in the national population at the time of the 2009 Census, with the exception of the Spanish-speaking Hispanics who have a younger age distribution when compared to the Hispanic population nationally.

The reported vaccination rate for the entire sample was 17%. This estimate is substantially lower than the official CDC estimate of 22.7% for adult H1N1 vaccine uptake for the monovalent H1N1 vaccine (CDC, 2011) [10]. Furthermore, the observed differences between racial/ethnic groups did not reflect the disparities observed nationally. A chi-square test of significance found no significant differences in vaccine uptake by racial/ethnic group, adjusted x^2=0.87 and p=0.83.

Table 3. Sample Demographics by Race/Ethnicity

	Non-Hispanic White	Non-Hispanic Black	Spanish-Speaking Hispanic	English-Speaking Hispanic	Total
Baseline Sample % (N)	N=991	N=194	N=229	N=65	N=1479
Sex					
Male	49 (502)	45 (89)	50 (110)	50 (35)	49 (736)
Female	51 (489)	55 (105)	50 (119)	50 (30)	51 (743)
Age					
18-29	19 (127)	26 (31)	35 (64)	18 (11)	21 (233)
30-44	23 (203)	28 (43)	40 (98)	27 (14)	26 (358)
45-64	30 (310)	28 (57)	21 (48)	23 (16)	28 (431)
65+	28 (351)	18 (63)	4 (19)	33 (24)	24 (457)
Longitudinal Sample % (N)	N=664	N=112	N=98	N=39	N=913
Sex					
Male	48 (340)	47 (52)	52 (46)	46 (21)	48 (459)
Female	52 (324)	53 (60)	48 (52)	54 (18)	52 (454)
Age					
18-29	21(81)	24(16)	38 (28)	22 (5)	23(130)
30-44	23 (117)	33 (26)	42 (38)	22 (5)	26(186)
45-64	30 (204)	25 (33)	17 (20)	27 (12)	28(269)
65+	27 (262)	18 (37)	3 (12)	28 (17)	24(328)
Vaccine Uptake	16 (121)	18 (25)	15 (17)	21 (11)	17 (174)

Note: Frequencies are unweighted, % are weighted be nationally representative

Vulnerability Index

Of the 1,479 adults sampled in the baseline survey, 95% report at least one source of vulnerability to H1N1, and 70% report two or more. Across the entire sample, the mean vulnerability score was 2.7 (SE=0.1). Analysis of variance indicated that mean vulnerability scores were significantly different by race/ethnicity, with F (3,11) =354.52 and p<.0001. Non-Hispanic Whites had the lowest vulnerability with a mean score of 2.3 (SE=0.1; range=0 to 9), followed by English-speaking Hispanics with mean of 2.7

(SE=0.3; range=0 to 7). Non-Hispanic Blacks had slightly higher vulnerability with a mean score of 3.1 (SE=0.1; range= 0 to 7). Spanish-speaking Hispanics had the highest levels of vulnerability with a mean of 5.1 (SE=0.1; range=1 to 9). The lowest score in the Spanish-speaking Hispanic sample was 1, indicating that every adult in this subsample had experienced a source of vulnerability.

Table 4, further highlights patterns in vulnerability across racial/ethnic groups. Of the nine vulnerability index components, chi-square tests of independence confirmed that all nine items were significantly different by race/ethnicity.

Table 4. Vulnerability Index by Race/Ethnicity

	Non-Hispanic White	Non-Hispanic Black	Spanish-Speaking Hispanic	English-Speaking Hispanic	Total	P value
Component % (N)						
Living in Poverty	10 (67)	21 (34)	39 (92)	12 (7)	15 (200)	<.0001
< High School Education	10 (53)	11 (16)	46(109)	20 (10)	14 (188)	<.0001
Children in Household	32 (274)	31 (56)	72 (166)	25 (65)	36 (514)	<.0001
Crowded Living Conditions	35 (319)	52 (88)	68 (147)	49 (34)	41 (588)	<.0001
Crowding	24 (210)	19 (29)	50 (104)	29 (19)	26 (362)	<.0001
Apartment	12 (112)	36 (63)	29 (67)	22 (16)	17 (258)	<.0001
Work-Related Polices*	87 (435)	87 (64)	98 (148)	91 (30)	89 (677)	0.01
Stay Home	72 (627)	61 (62)	87 (161)	74 (27)	73 (679)	<.0001
No Paid Leave	63 (346)	60 (55)	28 (48)	60 (24)	58 (473)	<.0001
No Sick Leave	46 (237)	48 (43)	81 (135)	58 (19)	51 (434)	<.0001
Social Distancing	47 (181)	83 (79)	80 (158)	70 (22)	59 (440)	<.0001
Public Daycare*	23 (66)	65 (32)	73 (118)	24 (3)	37 (221)	<.0001
Public Transportation	15 (138)	40 (67)	50 (112)	34 (19)	23 (336)	<.0001
Poor Health	47 (500)	65 (120)	30 (70)	47 (32)	48 (722)	<.0001
Chronic Condition(s)	46 (487)	62 (118)	28 (64)	46 (31)	46 (700)	<.0001
Immunodeficiency	12 (116)	14 (29)	11 (24)	6 (4)	12 (173)	0.41
Barriers to Health Care Access	22 (171)	30 (52)	80 (167)	25 (16)	29 (406)	<.0001
No Provider	15 (113)	20 (31)	63 (134)	18 (12)	20 (290)	<.0001
No Health Insurance	16 (123)	27 (45)	75 (154)	25 (15)	337 (24)	<.0001
Discrimination	6 (43)	25 (50)	41 (87)	15 (10)	12 (190)	<.0001
Mean Vulnerability (SE)	2.3(0.1)	3.1(0.2)	5.1(0.1)	2.7(0.2)	2.6 (0.1)	<.0001

Note: Total of 9 items, each **bolded** component counts as a single point. Frequencies are unweighted, % are weighted to be nationally representative

P-values for individual components were derived from adjusted Pearson x^2 tests.

P-value for mean vulnerability values were calculated through ANOVA.

* % of adults who reported working outside the home (N=764).

** % of adults who reported having young children (N=505).

For non-Hispanic Whites, the single most common source of vulnerability was from work-related risks. Of the non-Hispanic White adults in the workforce, 87% report one or more of the following work-related issues; a lack of paid leave, no sick leave, or they are unable miss 7-10 days of work if ill.

Compared to non-Hispanic Whites, non-Hispanic Blacks were more likely to live in poverty, live in multi-unit housing, or be unable to practice social distancing due to reliance on public transit or public daycare. However, the single largest source of vulnerability for non-Hispanic Blacks is from high levels of poor health. Non-Hispanic Blacks report the highest levels of poor health, with 65% of the sample reporting one or more chronic health condition or compromised immunity.

English-speaking and Spanish-speaking Hispanics had very different vulnerability scores which reinforced the decision to analyze the two groups separately. English-speaking Hispanics had similar levels of vulnerability as non-Hispanic Whites. One major difference between non-Hispanic Whites and English-speaking Hispanics was educational attainment, with twice as many English-speaking Hispanics (20%) reporting less than a high school education as non-Hispanic Whites (10%). English-speaking Hispanics were also more likely to report an inability to impose social distance (70%) than non-Hispanic Whites (47%), primarily due to a greater reliance on public transportation among English-speaking Hispanics (34%).

Spanish-speaking Hispanics reported the greatest level of vulnerability with a mean score of 5.1, more than twice that of non-Hispanic Whites (2.3). Of all racial/ethnic groups, Spanish-speaking Hispanics had the highest proportion of respondents below the poverty line (39%), less than high school education (46%), and crowded living conditions (68%). Spanish-speaking Hispanics also report the highest work-related vulnerability with nearly the entire working population (98%) reporting at least one policy that limits their ability to stay home, get paid leave, or take sick leave. The only area where Spanish-speaking Hispanics were not the most vulnerable, was in poor health. Only 30% of the Spanish-speaking Hispanic population had a chronic condition or compromised immune system, perhaps due to the relatively young distribution of this population. However, Spanish-speaking Hispanics also report the most barriers to healthcare access, with 63% reporting that they do not have a regular healthcare provider, and 75% reporting that they lack healthcare insurance.

Bivariate Analysis with Vulnerability Index

The vulnerability index score is a continuous measure. For additional bivariate analyses we utilized a categorical version of the index score by assessing the relationship between quartiles of vulnerability with both sex and race/ethnicity. A chi-square test of independence indicated a significant difference between sexes, adjusted x^2 = 13.15 and p=0.004. Differences were also significant by race/ethnicity, adjusted x^2 = 203.27 and p<. 0001. Table 5 details this bivariate analysis, displaying percentages for each quartile of vulnerability by race/ethnicity, stratified by sex.

Table 5. Bivariate Analysis of Vulnerability by Race/Ethnicity, stratified by Sex

	Vulnerability Quartile 1	**Vulnerability Quartile 2**	**Vulnerability Quartile 3**	**Vulnerability Quartile 4**	**P value**
Male, % (SE)					<.0001
NH White	24 (2.2)	33(2.6)	35(2.7)	8(1.8)	
NH Black	14(3.9)	16 (4.4)	55(6.6)	14 (4.7)	
EN Hispanic	2(1.5)	1 (0.6)	37(5.3)	60(5.4)	
SP Hispanic	22(8.1)	25(8.5)	33(8.8)	19 (9.3)	
Female, % (SE)					<.0001
NH White	36(2.7)	30 (2.5)	26 (2.5)	7(1.7)	
NH Black	12(3.9)	20(4.7)	47(6.3	21(5)	
EN Hispanic	2(1.1)	3(1.5)	25(4.7)	69(4.9)	
SP Hispanic	29(10.1)	24(9.2)	42(10.2)	5(3)	

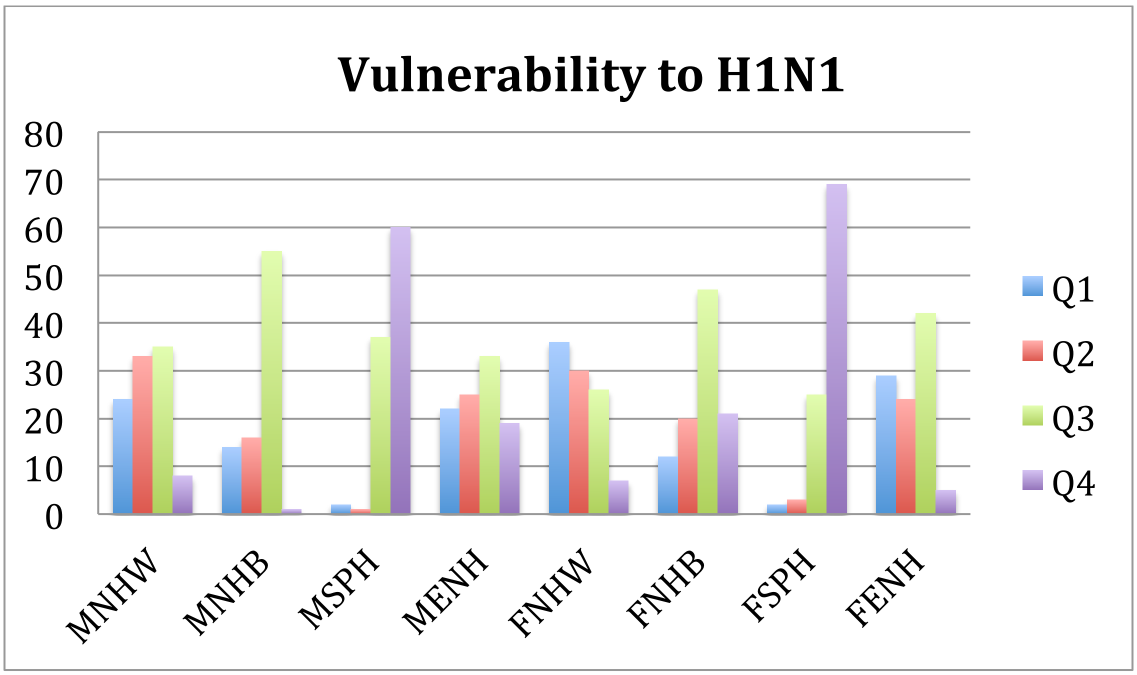
Note: Perceived vulnerability was measured using index scores. Answers were divided into quartiles from lowest vulnerability Q1 to greatest vulnerability Q4.
% are weighted to be nationally representative
P-values for differences by race/ethnicity were derived from adjusted Pearson x^2 tests

After stratifying, differences in vulnerability by race/ethnicity are significant for both males with p<. 0001 and females with p<. 0001. Among males, we see that non-Hispanic White men have the greatest representation in the first (24%) and second quartiles (33%), and low representation in the fourth quartile (8%). Non-Hispanic Black men are overwhelmingly represented in the third quartile (55%). English-speaking Hispanic men have roughly equal representation across all four quartiles, (22%, 25%, 33%, 19%, respectively). Spanish-speaking Hispanics have very low representation in the first two quartiles (2% and 1% , respectively) and a majority are represented in the fourth quartile (60%).

For females, a similar pattern across racial/ethnic groups is observed. Non-Hispanic White women have the lowest frequency in the highest quartile (7%) and Spanish-speaking Hispanic women have the highest frequency in the highest quartile

(69%). A close look reveals that non-Hispanic White women have slightly lower vulnerability when compared to non-Hispanic White men. However, this trend is reversed for both non-Hispanic Blacks and English-speaking Hispanics, where women report higher vulnerability scores when compared to men from the same racial/ethnic group. Both males and females of Spanish-speaking Hispanics have similar distributions. Figure 2 displays these frequencies by race/ethnicity, stratified by sex.

Figure 2. Vulnerability to H1N1 Quartiles by Race/Ethnicity, stratified by Sex.



Note: MNHW = Male, non-Hispanic White. MNHB= Male, non-Hispanic Black. MSPH= Male, Spanish-speaking Hispanic. MENH= Male, English-speaking Hispanic. FNHW= Female, non-Hispanic White. FNHB- Female, non-Hispanic Black. FSPH= Female, Spanish-speaking Hispanic. FENH= Female, English-speaking Hispanic.

Bivariate Relationships with Perceived H1N1 Risk

Preliminary analyses indicated an interaction between sex and race/ethnicity for the prediction of perceived H1N1 risk, therefore all analyses with the perceived H1N1 risk as the outcome was stratified by sex. For bivariate analyses we used the categorical variable of perceived H1N1 risk quartiles. A chi-square test of independence indicated significant differences in perceived H1N1 risk between sexes, adjusted x^2 =11.89 and p= <.008. Once stratified, further chi-square analyses confirmed significant differences in perceived H1N1 risk based on race/ethnicity in both the male with p<.0001 and the female group with p<.0001.Table 6 details the bivariate analyses, displaying percentages for each quartile of perceived H1N1 risk by racial/ethnic group, stratified by sex.

Table 6. Bivariate Analysis of Perceived H1N1 Risk and Race/Ethnicity, stratified by Sex

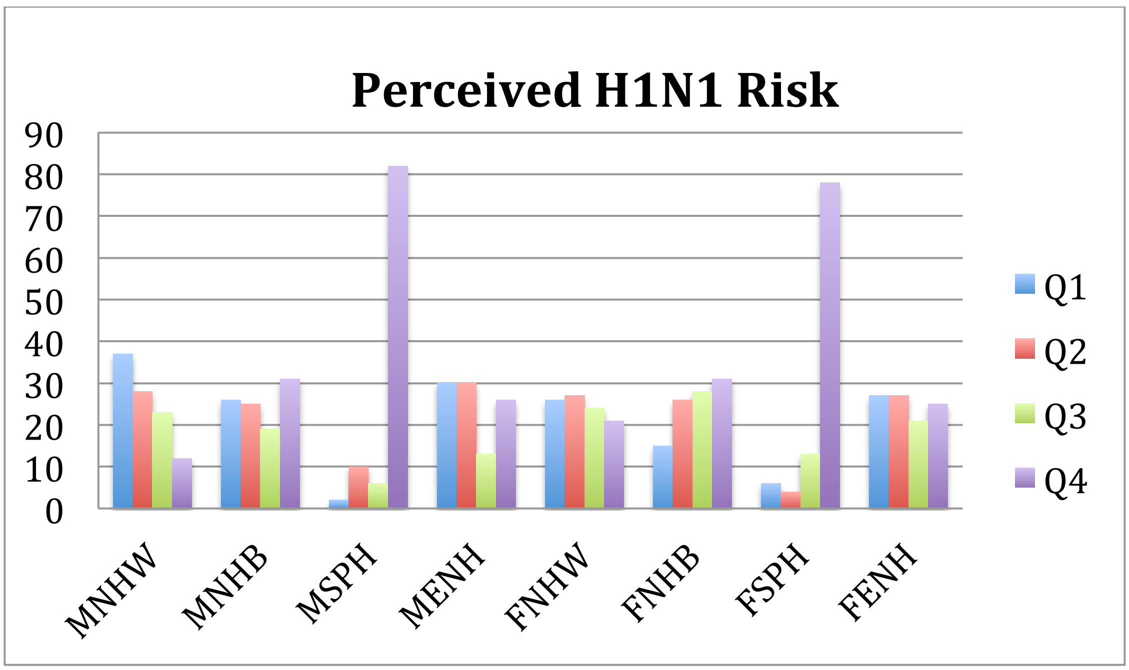
	Perceived H1N1 Risk Quartile 1	Perceived H1N1 Risk Quartile 2	Perceived H1N1 Risk Quartile 3	Perceived H1N1 Risk Quartile 4	P value
Male, % (SE)					<.0001
NH White	37 (2.7)	28 (2.4)	23 (2.5)	12(2.6)	
NH Black	26 (6.1)	25(5.7)	19(5.1)	31 (6.4)	
SP Hispanic	2(2.1)	10(3.8)	6 (1.9)	82 (4.5)	
EN Hispanic	30(8.7)	30 (9.3)	13 (6.4)	26 (9.2)	
Female, % (SE)					<.0001
NH White	26 (2.5)	27 (2.3)	24 (2.3)	21(2.4)	
NH Black	15 (4.4)	26(5.4.)	28(5.8)	31 (5.8)	
SP Hispanic	6 (2.1)	4(1.8)	13 (4.0)	78 (4.5)	
EN Hispanic	27(9.4)	27 (9.1)	21 (8.1)	25 (9.5)	

Note: Perceived risk was measured using the mean score for 5 risk- related items. Answers were standardized and then divided into quartiles from lowest perceived risk Q1 to greatest perceived risk Q4. % are weighted to be nationally representative.
P-values for differences by race/ethnicity were derived from adjusted Pearson x2 tests.

As predicted, non-Hispanic White men had the lowest perceived risk, with a greater proportion of non-Hispanic White men in the first (31.0%) and second (25.8%) quartiles and relatively few in the highest (14.5%) quartile. English-speaking Hispanic men were relatively evenly distributed across all four quartiles. Non-Hispanic Black men presented slightly higher levels of perceived H1N1 risk, skewing more into the third (26%) and fourth (32.3%) quartiles. Spanish-speaking Hispanic men showed the highest levels of risk, with less than <1% of the population falling into the lowest quartile of perceived risk and a majority of individuals falling into the highest (82%) quartile.

While women displayed higher levels of perceived H1N1 risk overall, the patterning of risk across racial/ethnic groups was also significant ($p < .0001$) and mirrors the distribution among men. Non-Hispanic White women displayed relatively consistent levels of risk across all four quartiles. English-speaking Hispanics closely resemble the Non-Hispanic Black women, both with a slight increase in the third and fourth quartiles. Similar to the men, 77.6% of Spanish-speaking Hispanic women were categorized in the fourth quartile, indicating the highest perceived H1N1 risk. Figure 3 displays these frequencies.

Figure 3. Perceived H1N1 Risk Quartiles by Race/Ethnicity, stratified by Sex.



Note: MNHW = Male, non-Hispanic White. MNHB= Male, non-Hispanic Black. MSPH= Male, Spanish-speaking Hispanic. MENH= Male, English-speaking Hispanic. FNHW= Female, non-Hispanic White. FNHB- Female, non-Hispanic Black. FSPH= Female, Spanish-speaking Hispanic. FENH= Female, English-speaking Hispanic

Linear Regression Model Results

Further testing to determine whether race/ethnicity, sex, and vulnerability each function as independent predictors of perceived H1N1 risk was conducted using multiple linear regression modeling. Table 7 outlines the full results. First we used a model to predict perceived H1N1 risk responses based on race and sex only, and then expanded the model to include quartiles of vulnerability. Model 1 demonstrates that the impact of race/ethnicity alone was highly significant, for both males with $F= 2684.05$, $df= 9$, $p<.0001$ and females with $F =251.56$, $df=11$, $p <.0001$. However the inclusion of vulnerability in Model 2 increased the explanatory power of the model, for both males $F=7015.67$ $df=9$, $p <.0001$ and females $F=244.03$, $df=11$, $p <.0001$. While the R^2 values for the models were quite modest, they increased by 0.03 from Model 1 to Model 2, for both men, (from 0.21 to 0.25) and women (from 0.12 to 0.14).

The observed differences between racial/ethnic groups were stronger for males than for females. In the full model, the β estimates for males were slightly larger in both race/ethnicity and for vulnerability. The graded relationship between vulnerability and perceived H1N1 risk was also steeper for men, when compared to women.

Table 7. Adjusted Linear Regressions of Perceived H1N1 Risk by Race/Ethnicity and Vulnerability, stratified by Sex.

	Model 1			Model 2		
	β	P>|t|	R2 Value	β	P>|t|	R2 Value
Male						
Race/Ethnicity						
NH White*	--	---	0.21	--	----	0.25
NH Black	0.39	<.0001		0.33	0.04	
SP Hispanic	1.56	<.0001		1.41	<.0001	
EN Hispanic	0.18	0.18		0.14	0.95	
Vulnerability						
Quartile 1*				--	---	
Quartile 2				0.07	0.42	
Quartile 3				0.28	<.0001	
Quartile 4				0.56	<.0001	
Female						
Race/Ethnicity						
NH White*	--	---	0.12	--	---	0.14
NH Black	0.31	0.01		0.22	0.04	
SP Hispanic	1.22	<.0001		0.97	<.0001	
EN Hispanic	0.15	0.15		0.13	0.30	
Vulnerability						
Quartile 1 *				--	---	
Quartile 2				0.00	0.98	
Quartile 3				0.22	0.01	
Quartile 4				0.42	<.0001	

Note: All analyses adjusted for age, continuous in years.
*Reference category

Logistic Regression Model Results

Binary logistic regression was used to examine vaccination behaviors for H1N1 vaccine, by sex, race, vulnerability, and level of perceived risk to H1N1, while controlling for age continuous in years. Table 8 displays the full results. First we ran a model including only sex and race/ethnicity, adjusting for age. Model 1 did not detect any significant associations between vaccine uptake and the independent variables of sex and race/ethnicity. Model 2 added quartiles of vulnerability in addition to sex and race/ethnicity. Again, the model did not detect significant associations between vaccine uptake and independent variables. Model 3 added quartiles of perceived H1N1 risk to create a full model that included sex, race/ethnicity, vulnerability, and perceived H1N1 risk as independent predictors.

Logistic regression of the full model did not detect significant relationships between vaccination and the independent variables of sex, race/ethnicity, or vulnerability, but did find a significant association between perceived H1N1 risk and vaccine uptake. A positive, graded relationships between perceived H1N1 risk and vaccine uptake was observed. The odds of getting vaccinated increased with each quartile of perceived H1N1 risk. The odds of getting vaccinated were 3.01 times higher for individuals who reported the highest quartile of perceived H1N1 risk when compared to those who reported the lowest quartile. No interactions between sex, race/ethnicity, vulnerability, and perceived H1N1 risk were detected.

Table 8. Adjusted Logistic Regressions of H1N1 Vaccination by Sex, Race/Ethnicity, Vulnerability, and Perceived H1N1.

	Model 1			**Model 2**			**Model 3**		
	OR	95% CI	P>|t|	OR	95% CI	P>|t|	OR	95% CI	P>|t|
Sex									
Male*	1.00	---	---	1.00	---	---	1.00	---	---
Female	1.03	(0.65-1.55)	0.99	1.02	(0.65-1.58)	0.94	0.97	(0.62-1.52)	0.88
Race/Ethnicity									
NH White*	1.00	---	---	1.00	---	---	1.00	---	---
NH Black	1.35	(0.65-2.77)	0.73	1.31	(0.65-2.67)	0.65	1.16	(0.56-2.39)	0.67
SP Hispanic	1.13	(0.54-2.35)	0.82	0.95	(0.36-2.44)	0.58	0.71	(0.27-1.83)	0.39
EN Hispanic	1.42	(0.59-3.39)	0.64	1.44	(0.60-3.38)	0.54	1.38	(0.60-3.17)	0.39
Vulnerability									
Quartile 1*				1.00	---	---	1.00	---	---
Quartile 2				1.25	(0.74-2.11)	094	1.26	(0.74-2.14)	0.57
Quartile 3				1.18	(0.67-2.08)	0.82	1.07	(0.74-2.14)	0.78
Quartile 4				1.56	(0.59-4.12)	0.48	1.21	(0.49-2.97)	0.83
Perceived H1N1 Risk									
Quartile 1*							1.00	---	---
Quartile 2							1.75	(0.97-3.17)	0.92
Quartile 3							1.67	(0.88-3.14)	0.87
Quartile 4							3.01	(1.63-5.54)	0.01

Note: Based on the probability of getting vaccinated. All analysis weighted and adjusted for age continuous in years.
* Reference Group

Chapter 5: Discussion

Discussion

This study adds to existing literature on social inequality and the H1N1 Pandemic in three areas: first, this study confirms that increased vulnerability to H1N1 disproportionately affects non-White populations, especially non-Hispanic Blacks and Spanish-speaking Hispanics; second, it demonstrates that sex, race/ethnicity and vulnerability are significantly associated with perceived H1N1 risk, supporting the "Social Inequality Effect" in risk perception; and third, it indicates that perceived H1N1 risk has a positive, graded effect on vaccine uptake. These three key findings have theoretical significance and practical implications for pandemic preparedness.

Our results demonstrate a positive association between H1N1 vulnerability and non-White race/ethnicity. When compared to non-Hispanic whites, non-Hispanic Blacks reported 34% greater vulnerability to H1N1, and Spanish-speaking Hispanics reported 120% greater vulnerability to H1N1. This empirical evidence supports the argument that social inequality and existing health disparities contribute to greater vulnerability for disease during an influenza pandemic. It also supports recent findings that influenza disproportionately affects the poor, the disadvantaged, and socially marginalized [15, 41].

The fact that vulnerability and racial/ethnic status are closely aligned but not identical is also important. The 9-item vulnerability index captures the nuances of this relationship in two ways. First, since the vulnerability score captures disadvantage due to social context and disparities in health, it indirectly captures the social effects of minority status. This allows the vulnerability score to capture heterogeneity within racial/ethnic group allowing for a more nuanced approach to better characterize racial/ethnic health disparities.

Second, the 9-item vulnerability index also captures the cumulative effects of multiple disadvantages in a single measure. Quinn et al. demonstrated that disparities in exposure, susceptibility, healthcare access and discrimination independently contributed to a differential burden of risk for H1N1[2]. The 9-item vulnerability index takes these findings further by combining independent measures of disparity with measures of structural inequality (low education and poverty) to create a single measure that better captures the additive effects of multiple disparities. The vulnerability scores demonstrate that non-Hispanic Blacks and Spanish-speaking Hispanics face the greatest vulnerability to disease due to disparities at multiple levels act together.

This study also demonstrated systematic differences in perceptions of H1N1 risk, suggesting that the "Social Inequality Effect" may explain patterns of perceived H1N1 risk. We found significant differences in perceived risk by sex, with women reporting greater perceived H1N1 risk than men. Within sex, we also found significant differences based on race/ethnicity with non-Hispanic Blacks and Spanish-speaking Hispanics reporting greater perceived H1N1 risk than non-Hispanic Whites. Additional analysis confirmed a positive relationship between vulnerability and perceived H1N1 risk. When taken together these trends suggest that the observed effect is more nuanced than the standard "White Male Effect" and that the idea of the "Social Inequality Effect" better captures these findings. Not only does this better capture the graded nature of the findings, it also underscores the significant heterogeneity in social position that exists within sex, and within racial/ethnic group.

Finally, our results show that H1N1 vaccine uptake is associated with perceived H1N1 risk. That is, we observed a positive, graded relationship between perceived H1N1 risk and vaccination, with odds of vaccination increasing across each quartile of reported H1N1 risk. Individuals reporting the highest perceived H1N1 risk, had more than 3 times the odds of vaccination than individuals reporting the lowest perceived H1N1 risk. This is an important finding since many articles document the evolution of H1N1 risk perception over the pandemic period, opinion polls indicate that early in the pandemic, the public reported high levels of concern, but by the time the H1N1 vaccine was released media coverage had declined and public perception of risks had decreased [21, 42]. One longitudinal study even tracked the decline in vaccine intentions over this period [43]. Our finding suggests that reports of greater perceived H1N1 risk in June remained salient months later when seeking an H1N1 vaccine.

The issue of vaccine uptake is complicated by the reported vaccination rates in the longitudinal sample. Racial/ethnic disparities in vaccine uptake were reported in CDC estimates but none were evident in our research sample. We predicted independent associations between vaccination and sex, race/ethnicity, vulnerability and perceived H1N1 risk perception. However, we did not detect significant relationships between vaccination and any of the independent variables except for perceived H1N1 risk in the full model.

However, modeling vaccine uptake is complex. Many additional factors may be involved, including fear of vaccine side effects and or mistrust of the vaccine. Similar studies on H1N1 vaccine uptake have not provided conclusive evidence on this issue. Some studies found sex and race/ethnicity alone to be insignificant predictors for vaccination [44]. Another study found race/ethnicity to be significant, with Black populations reporting significantly lower vaccination rates, when compared to White and Hispanic populations [45].

Strengths & Limitations

Strengths

The strengths of this study include the use of a nationally representative sample, with intentional oversampling of non-Hispanic Blacks and Hispanics. This sample includes relatively large samples of both Hispanics and non-Hispanic Blacks, making it possible to make comparisons across racial/ethnic groups. The distinction between Spanish and English language for the survey also makes it possible to assess differences within the larger Hispanic population.

The greatest strength of this research is the use of a longitudinal sample. Most survey research on vaccination relies on a single survey or a series of cross-sectional surveys. This research is one of only a handful of studies to utilize a true longitudinal sample to assess the H1N1 influenza pandemic.

Limitations

Our study has several limitations. The difference between baseline and follow-up survey populations may reflect nonrandom losses to follow-up. However the important temporal element of using two data collected at two separate points in time made this data valuable. The low reported vaccine rates for the longitudinal subsample may be due to respondent bias, since the survey relied on self-report data and later studies have demonstrated confusion over the two terms "swine flu" and "H1N1 influenza" among the general public. The fact that two separate "flu" vaccines were offered in 2009-10, the standard trivalent seasonal influenza vaccine and the separate monovalent H1N1 influenza vaccine, may have added an additional element of confusion for respondents.

Directions for Future Studies

The results of this research raise several key issues related to the role of social inequality during influenza pandemics specifically, and other infectious disease outbreaks more broadly.

There are many possibilities to incorporate the vulnerability index into future research. Since the index consists of both general measures of social vulnerability as well as disease-specific measures of disparities, aspects of the scale could be adapted to fit different infectious disease scenarios. This could be very useful for emergency preparedness related to emerging infectious disease.

Future research should embrace the broader concept of the "Social Inequality Effect" instead of the narrower "White Male Effect". This research demonstrated that it is possible to apply the broad concept of the "Social Inequality Effect" in perceived risk to a single source of risk, namely vaccine preventable illness. Future research could explore the role of this effect related to other vaccine preventable illnesses; including seasonal influenza, childhood immunizations, or vaccines currently in development. It would also be interesting to assess the role of the "Social Inequality Effect" in perceived risk related to fear of vaccine side effects.

Finally, this research highlights the need to incorporate more intersectional approaches into risk research. Risk analysis needs to move beyond differences based on sex and race/ethnicity to incorporate vulnerability in future analysis. This is especially relevant as social inequality continues to deepen exisiting disparities across a wide range of health outcomes.

Public Health Significance

The results of this study have practical implications to address many of these remaining concerns. During a pandemic, it is to be expected that resources will be limited. Instead of directing resources to the entire population, greater attention needs to be directed to populations with greatest vulnerability, especially non-Hispanic Blacks and Spanish-speaking Hispanics. The extreme vulnerability of Spanish-speaking Hispanics is a source for concern and suggests that in a future pandemic special consideration should be made to reach this group. It is also important to note the different sources of vulnerability between racial/ethnic groups and tailor intervention strategies to better match specific population needs. For non-Hispanic Blacks, the high burden of chronic disease lends itself to intervention strategies that target more susceptible individuals. For non-Hispanic Whites, the high proportion of working individuals who experience work-related vulnerability, a stronger push for policy intervention that encourages increased employer benefits and paid sick leave may be beneficial.

It has been six years since the H1N1 pandemic ended. From the perspective of present day, we can see the some of the flaws of the emergency response and vaccination campaign. Some of these issues have been addressed. For instance, as a direct impact of the H1N1 pandemic, the ACIP started endorsing “universal” recommendations for annual seasonal flu vaccination, shifting away from priority groups to encourage all individuals older than 6 months to get immunized. Also, sweeping reform in healthcare access related to the Affordable Care Act have also made it possible for many more millions of Americans to get access to providers and receive recommended immunizations at no-cost. However, the intervening 6 years have not removed most of the social conditions that contribute to vulnerability for influenza infection. In the current political climate issues related to income inequality, racial/ethnic identity, gender identity, immigrant status, and healthcare policy are all heavily debated. It may not be feasible to eradicate social inequality, but public health efforts need to be more aware of the various ways inequality structures experiences of infectious disease.

Conclusions

This research utilized an intersectional approach to explore the impacts of social inequality during the H1N1 pandemic. Our results confirm that non-Hispanic Blacks and Spanish-speaking Hispanics experienced greater vulnerability to influenza. Greater vulnerability, along with female sex and non-White racial identity contributed to greater perceived H1N1 risk. This patterning followed the "Social Inequality Effect". Finally, perceived H1N1 risk was a significant predictor for vaccine uptake. Future pandemic preparedness efforts should consider the impact of social inequality to better identify the most vulnerable individuals and to better allocate scarce resources during an emerging health crisis.

Appendices

MPH COMPETENCIES ADDRESSED IN THESIS

The following table illustrates the complete list of MPH competencies that were addressed in this thesis.

Competencies for MPH in Epidemiology	Thesis	Addressed in this Thesis
1) Demonstrate the importance of epidemiology for informing scientific, ethical, economic, and political discussion of health issues	Yes	Epidemiological support for the role of social inequality during an influenza pandemic
2) Assess a public health problem in terms of magnitude, person, time, and place.	Yes	Examined factors associated with pandemic influenza vulnerability, perceived risk, and vaccination.
3) Distinguish the basic terminology and definitions of epidemiology	Yes	Statistical analysis and interpretation of results
4) Discriminate key sources of data for epidemiological purposes	Yes	Use of national survey data
5) Calculate basic epidemiology measures.	Yes	Descriptive statistics
6) Identify the principles and limitations of public health screening programs	No	Internship
7) Evaluate strengths and limitations of epidemiologic reports	No	Strengths and weaknesses
8) Draw appropriate inferences from epidemiologic data.	Yes	Results and discussion sections
9) Explain criteria for causality.	Yes	Results and discussion sections
10) Calculate advanced epidemiologic measures.	Yes	ANOVA, linear regression modeling, logistic regression modeling, adjusted and unadjusted Odds Ratios.
11) Communicate epidemiologic information to lay and professional audiences.	Yes	Written thesis report; Oral thesis proposal and final presentation of results and public health significance to audiences. Presentation at professional conference.
12) Compare basic ethical and legal principles pertaining to	Yes	IRB approval

the collection, maintenance, use and dissemination of epidemiologic data.		
13) Design, analyze, and evaluate an epidemiologic study.	Yes	Design, conduct, and write up thesis.
14) Design interventions to reduce prevalence of major public health problems.	No	Discuss public health significance, future research, and policy implications
15) Demonstrate program administration and organizational leadership.	No	Internship

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