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Abstract

Objective

Influenza vaccination coverage in the US is below CDC-recommended levels of 80%, especially among elderly African Americans. There is an urgent need for interventions to promote vaccination. The purpose of this analysis is to explore multilevel factors, including those at the individual and neighborhood-levels,to explore influences on influenza vaccination decisions among older African Americans ages 50-89 years. This study also describes if and how these factors work as facilitators and barriers to seasonal influenza immunization among this group.

Methods

Study subjects were recruited from faith-based settings, were aged 50 and over, and were Black/African American. Participants were enrolled in the Dose of Hope study, where they completed questionnaires that assessed demographics, health attitudes, knowledge, and behaviors. Influenza vaccination in the 2012-2013 season was the outcome of interest. Models used hierarchical linear model procedures to assess census-tract level factors including a neighborhood deprivation index specific to Atlanta, violent crime rates, neighborhood racial makeup, vehicle availability, and vacant housing. The models also included individual educational attainment level, gender, age, perception of neighborhood security, and attitudes toward vaccinations.

Results

Participants' older age was found to be significantly associated with influenza vaccination, along with their perceived security of their own neighborhood and their attitudes toward vaccination. At the neighborhood-level, the percentage of vehicles functioned as a proxy for area affluence and transportation ease and corresponded with participants' perceived residential area physical security. This factor also was significantly associated with influenza vaccination after adjusting for knowledge and attitudes toward vaccinations.

Conclusion

The findings indicate that neighborhood-level factors play an important role in motivating influenza vaccination decision-making among older African Americans. The study described an important pathway that linked distal neighborhood-level factors to individual characteristics and perceived security. The findings suggest that higher neighborhood affluence, transportation ease, and perceived neighborhood security influence seasonal influenza immunization uptake among vulnerable older African Americans. Further study of other neighborhood and individual-level effects in this population are needed to understand how to design effective interventions and more effectively address vaccine-preventable disease disparities.

Acknowledgements

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Chapter I

Introduction

Influenza, the flu, is a common illness affecting 5-20% of the U.S. population (1, 2). This disease affects the respiratory tract and can cause symptoms including fever, cough, sore throat, runny nose, muscle and headaches, and fatigue (3). The disease is usually self-limiting; however, there are complications of the flu that can occur in specific at-risk groups.

Those at risk for these complications include those with chronic diseases or infections, since influenza can exacerbate these conditions (4, 5). Also at risk for complications are those who are over the age of 65 (5). In the 2012-2013 flu season, the rate of hospitalization among flu cases was 180 per 100,000 in those aged 65 and over, compared to only 70 per 100,000 or lower among all other age groups (6).

Seasonality of the flu can be attributed to the ways that the virus is able to change its characteristics over time. The slight changes lead to variants of the flu that emerge each year and causes the number of cases to peak during flu season.

The best method of protection against this virus is the annual influenza vaccine. The vaccine is not mandatory; however, the Healthy People 2010 goal was to achieve 90% vaccine coverage, and the CDC recommends that all individuals above age 6 months get the influenza vaccine each year (7-9). Despite recommendations, vaccine coverage is only 60% among Medicare beneficiaries, and is particularly low, 48%, among elderly African Americans (2) (8, 10).

Some of the reasons that individuals do not get vaccinated could include the cost of vaccinations, lack of medical insurance, lack of access due to transportation or safety,

and lack of awareness or understanding of the importance of the vaccine. In order to understand barriers to vaccination, it is important to not only focus on individual characteristics of the unvaccinated, but to look at population-level factors.
Studies that use neighborhood-level effects to understand vaccinations outcomes have been useful for understanding the ways that the environment plays a role in individual attitudes and behaviors.

The goal of this analysis is to explore the use of neighborhood-level characteristics to describe self-reported vaccination outcomes. Using specific census-level variables, models will be constructed to demonstrate how these factors are associated with decisions to get influenza vaccinations. The hope is that by exploring which factors are significantly associated with influenza vaccination, more specific interventions and policies can be implemented that will better meet the needs of their target populations.

This analysis will focus on a cohort of older African Americans residing in Atlanta, who were recruited through their regularly attended churches. A cross sectional study examining health knowledge, attitudes, and decisions provides data on individual characteristics and self-reported influenza vaccination. Census data matched with these participants based on their place of residence provides a way to link neighborhood-level characteristics with individuals and determine what role, if any, these outside factors play in vaccination decisions. The analysis was based on the following four research questions:

Research Question 1: How do neighborhood deprivation score, neighborhood racial makeup, and neighborhood affluence predict vaccination decisions?

Research Question 2: Is there an association between perceived neighborhood security and vaccine attitudes and vaccination decisions?

Research Question 3: Is there a multi-level effect between neighborhood-level and individual-level characteristics as predictors of influenza vaccination?

Research Question 4: Are there other demographic factors that modify the relationship between these neighborhood-level factors and vaccination decisions?

Chapter II

Literature Review

Introduction to Influenza Illness

Influenza, known colloquially as the flu, is a common illness affecting 250,000 to 500,000 people annually worldwide, and 5-20% of the U.S. population (1, 2). This disease affects the respiratory tract and can cause a mild to severe illness. Common symptoms of the flu include fever, cough, sore throat, runny nose, muscle and headaches, and fatigue (3). It usually develops with a sudden onset of symptoms, and is often limited to the upper respiratory tract, though possibly could manifest in gastrointestinal effects (7). The symptoms usually last for a few days up to 2 weeks (11). The disease is usually self-limiting; however, there are complications of the flu that can occur in specific, at-risk groups.

Burden of Disease and Consequences of Influenza Infections

Complications of influenza include pneumonia, pulmonary and cardiovascular disease, and neuromuscular conditions. Those at risk for these complications include those with chronic diseases or infections such as heart, lung, or renal disease, diabetes, dementia, stroke, cancer, and HIV, since influenza can exacerbate these conditions (4, 5). Also at risk for complications are those who are immunocompromised, pregnant, or over the age of 65. These sequelae often lead to poor fetal health outcomes, hospitalization, and possibly death (12). The risk of hospitalization or death among those possessing any of these characteristics can be 30-fold higher than in healthy individuals, and the elderly are especially affected if they have pre-existing conditions (4).

It is estimated that there are 200,000 influenza-related hospitalizations annually, and the hospitalization rate has increased each year since 1991 in the elderly (13, 14). In the 2012-2013 flu season, the rate of hospitalization among flu cases was 180 per 100,000 in those aged 65 and over, compared to only 70 per 100,000 or lower among all other age groups (6). It is estimated that there are about 23,000 deaths attributed to influenza each year in the US, and 90% of these deaths occur in those aged 65 and over (15). The risk increases as age increases; one study found that those aged 85 and over were 16 times more likely to die from the flu than those aged 65-69 (1).

Influenza Symptoms and Treatment

Influenza affects the respiratory tract and must enter the nose or mouth in order to cause infection. The flu is transmitted through close human contact through mucus or saliva, often by coughing, sneezing, talking, and shared objects or surfaces (16). Because the disease is usually self-limiting, treatment of the flu is focused on managing symptoms, such as making sure the infected person gets plenty of rest and fluids. Over-the-counter medications can be taken to help reduce pain and lessen other symptoms (17).

Because influenza is caused by a virus, specific anti-viral medications have been developed to combat the illness, the most common being Tamiflu, Relenza, and Rapivab (17). More antiviral drugs exist, however some have been discontinued due to the virus' ability to become resistant to their effects. Researchers and physicians agree that washing hands and avoiding ill persons are some ways to stay healthy, however a more effective method exists.

Influenza Virology

The influenza virus is part of the orthomyxovirus family and is an RNA virus. Differences in these RNA sequences have created three strains: A, B, and C, with A being the most common cause of human infections (18). Within these strains, viruses can be typed based on their surface proteins, hemagglutinin (HA) and neuraminidase (NA). Current research has discovered influenza viruses are capable of creating 16 different HA and 9 different NA proteins, all numbered 1-16 and 1-9 respectively. Influenza viruses H1N1, H2N2, and H2N2 have circulated widely in humans, while others such as H5N1 and H7N9 have caused sporadic infections throughout history (7).

Flu season has been traditionally ascribed to the months of October through May (19). Seasonality of the flu can be attributed to the ways that the virus is able to change its characteristics over time. Influenza viruses undergo two types of genetic change: antigenic shift and antigenic drift. Antigenic drift, occurs when the virus develops point mutations within its genetic sequence, leading to mutations in the HA and NA antigens on its surface. Antigenic shift occurs when the virus undergoes abrupt changes in genetic sequences, often when two different virus types experience genetic re-assortment within a host animal or human cell and create a virus with a new combination of HA and NA. The new viruses created by antigenic shift are what can cause pandemics by introducing a new virus type into a naive population (18). The slight changes caused by antigenic drift lead to variants of the flu that emerge each year and causes the number of cases to peak during flu season.

Influenza Vaccination Facts

Researchers must develop a method of protection that can keep up with the dynamic nature of this virus. The best method of protection against this virus is the annual influenza vaccine. It has existed since the 1940s, and contains the inactivated or killed forms of the virus that has been predicted to be in circulation during each year's flu season. There are three forms of the influenza vaccine, the inactivated influenza vaccine (IIV), live attenuated influenza vaccine, and recombinant influenza vaccine (15). The IIV is the most common and is am injection recommended for those aged 18 to 64 (15). The trivalent form contains two strains of influenza type A and one strain of influenza type B, and is recommended for those 6 months and over (15). The quadrivalent vaccine contains the same three plus an additional influenza B inactivated virus, and can be injected or administered intranasally (19). There are also high dose forms of the vaccine for those over the age of 65, or those possessing other risks for complications (15).

Benefits to Influenza Vaccination

The vaccine is not mandatory; however, the CDC recommends that all individuals above 6 months of age get the influenza vaccine each year (7). The Advisory Committee on Immunization Practices of the CDC recommends universal influenza vaccination for those over the age of 65 (15). The trivalent vaccine is recommended for all ages, while the quadrivalent vaccine is recommended for healthy children 2-8 years of age, and not necessarily for those over age 60 (19, 20). A preliminary analysis of vaccine effectiveness for the 2012-2013 influenza season found that the marketed vaccine was on average 62.2% effective in preventing incidence of laboratory confirmed influenza in five European countries, though in specific regions, the effectiveness was as high as 73% in specific regions (21). Previous analyses of vaccine effectiveness in the U.S. have shown 70-90% effectiveness in those under age 65, and 58% in those over age 60 (22).

The benefits to vaccination are not limited to individual health outcomes. Vaccination on a national scale benefits the US economy greatly. The costs due to treatment, hospitalization, and hours of labor lost from absenteeism all affect our nation's economic growth, and this occurs every year as new strains of influenza continue to emerge (13). It is estimated that influenza illness accounts for between 0.6 and 2.5 lost work days per individual infected (1). Influenza illness costs the U.S. an estimated $11-18 billion in direct and indirect costs each year. Vaccinating would save a large proportion of this money by eliminating the costs of hospitalization and lost productivity (1). It is estimated that vaccinating everyone over age 65 would save about $80 per person and reduce hospitalizations and deaths by 33% (5).

Disparities in Vaccination Coverage

Despite these recommendations and the burden of disease, there are many who do not get vaccinated. In order to confer adequate protection, the World Health organization suggests vaccine coverage rates of 80% or higher in a population, while the Healthy People 2010 goal was to achieve 90% vaccination coverage (8, 23, 24). The goal is to achieve herd immunity, where a large proportion of a population is vaccinated so that the chance that an unvaccinated person will become vulnerable to viral transmission is very low. It is estimated that among Americans eligible to receive the flu vaccine, coverage is only 38% (25). Young children and healthcare workers have the highest vaccine coverage, however among Medicare beneficiaries, coverage is only 60%, and coverage is particularly low, 48%, among African Americans (2, 8, 10). In a study examining vaccine coverage in white and black races, whites were significantly more likely to be vaccinated (aOR=1.52) compared to blacks, even after adjusting for physician-patient relationship, and other individual and environmental factors (2).

Barriers to Vaccination

Some of the reasons that individuals do not get vaccinated could include the cost of vaccinations, lack of medical insurance, lack of access due to transportation or safety, and lack of awareness or understanding of the importance of the vaccine. Specifically among the Medicare-eligible population, age, health status, education, income, knowledge and attitudes toward immunization, insurance coverage, regularity of care, and HMO enrollment are all factors related to influenza vaccination decisions (2). Some studies have focused on factors such as perceived susceptibility, and personal beliefs about vaccinations. In a study comparing blacks and whites, vaccination rates were comparable between the two races when controlling for perceptions of immunizations (26).

Comparing self-reported influenza vaccination rates in those under 65, blacks were just as likely to be vaccinated as whites in overall analyses. Yet, among those with chronic conditions, blacks were significantly less likely to be vaccinated if they had asthma or hypertension. Among those over 65, blacks were significantly less likely than whites to be vaccinated overall, and with the presence of a chronic disease, hypertension, or hypercholesterolemia (5). It is hypothesized that in minority populations, especially blacks, barriers to vaccination could include a physician's willingness to promote vaccination, as evidenced by physician hesitancy to promote other health-seeking behaviors and treatments such as dialysis or organ transplants to minority patients (5). Another study developed a predictive model of willingness to receive a flu shot that included multiple factors. These include: perceptions of likelihood of getting the vaccine, severity of illness, inconvenience of illness to family or friends, vaccine effectiveness, vaccine side effects, cost of vaccination, previous history of illness or vaccination, and amount of time a person was willing to wait to receive a benefit, anxiety toward health, along with demographic characteristics such as education and marital status (22).

Interventions to Increase Vaccination Coverage

Based on these known barriers, there have been attempts to increase vaccination coverage. In some states, pharmacies have been required to include influenza vaccinations with their usual services (13). Pharmacies have the benefits of short wait times, convenient locations, affordable options, and late hours which can accommodate a wider range of individuals, including racial minorities and those with low income (13). National data has shown an over-all increase in influenza vaccination coverage due to programs like these, though interestingly, the initiative has been well received among white and immigrant neighborhoods, but not as well received among neighborhoods with many racial minorities (13). Some interventions focus on specific at-risk groups; there have been efforts to encourage influenza vaccination among pregnant women who often develop more severe influenza symptoms (12). The elderly are also a target of interventions; although there was some thought that focusing on prevention in elderly populations was unnecessary, it has actually been shown to be important and highly cost-effective (23). Improving access by giving vaccination coupons, or screening populations in nursing homes or other places increases convenience and allows for a way to identify the unvaccinated (23).

Overcoming these barriers and remaining motivated to choose healthy behaviors requires an internal motivation that may be strengthened or weakened by outside factors. These motivations can be explained by the Theory of Reasoned Action, which states that human behavior can be predicted by the intention to engage in that behavior, which is then related to attitudes toward completing that behavior (27). The Theory of Planned Behavior takes this one step further, saying that behavior is determined by intentions, which are determined not only by attitudes, but by perceived social support and self-efficacy (27).

In the case of complex decisions such as vaccinations, there is an interplay of attitudes, intentions, and behaviors; all of which must be captured to understand vaccination coverage. In a study applying these theories to Human Papilloma Virus vaccination among males and females, males who intended to be vaccinated had a greater amount of perceived support than males who were not vaccinated (p value <0.01), and that over all, the components of the Theory of Reasoned Action explained a large proportion of the variability of vaccination status between sexes (27). Another study applied the Theory of Reasoned Action along with the Triandis model, a model specific to health behavior that accounts for “facilitating conditions, habits, attitudes, social influences, and perceived consequences,” when predicting health behaviors (8). A predictive model for health-related behaviors that applied the Triandis model included ease of access to the facility, history of getting the vaccine, attitudes toward vaccination, physician recommendation, and perceived value of getting a vaccine (8).

Although these theories are able to describe some of the mechanisms behind health behaviors, it is possible that other group-specific factors could influence intentions, such as historical events like Tuskegee that could lead African Americans to be wary of the health care system as a whole (28).Even so, these factors alone may not be enough to explain the disparities in vaccination coverage. In order to understand barriers to vaccination, it is important to not only focus on individual characteristics of the unvaccinated, but to look at broader, more population-level factors. In the analysis of factors related to influenza vaccination among the elderly, it was found that as many as 98% of those aged 66 and over were aware of the importance of vaccines (8). Racial differences in vaccination coverage were not simply explained by demographics such as age, sex, education, health status, insurance status, or regularity of physician visits; these factors only explained 7% of the difference in likelihood of influenza vaccination between whites and blacks (OR=1.9) (2). When including county-level variables such as provider availability, socioeconomic status, and medical culture, more variation was explained (2).

Studies that use neighborhood-level effects to understand vaccinations outcomes have been useful for understanding the ways that the environment plays a role in individual attitudes and behaviors. In a Canadian study, vaccination coverage was obtained and compared to demographic as well as census-level indices of material and social deprivation that were related to socioeconomic status of the surrounding neighborhood (10). Influenza vaccination uptake in Canadian clinics in diverse locations was significantly influenced by population density, violent crime rates, and material deprivation of the area where the clinic was located (29).

A neighborhood deprivation index (NDI) was developed by Messer and colleagues in 2006. Using 2000 census data, area-level variables thought to be related to their specific outcome of preterm birth were gathered from the literature and then assessed using specific cities across the United States using principle component analysis (30). The remaining eight variables that were not dropped after this analysis were: percentage of female headed households with dependents, unemployment rate, percentage of households under the poverty line, percentage of households receiving public assistance, percentage of households with income under $30,000, percentage of crowded households (defined as more than one person per room), percentage of males in management and professional positions, and percentage of population with less than high school education (30). The factor loading scores for each of these variables were applied to the values for each city and summed to create a single index value for each census tract (30). This index has since been applied to a variety of outcomes, from births to health-seeking behaviors and obesity, and because it contains many of the aforementioned factors that have been significantly associated with influenza vaccination, it has potential to be a predictor of influenza vaccination.

Chapter III

Methods

Study Design

The data for this analysis was taken from the Dose of Hope (DoH) baseline and 3 month surveys and collected from the US Census Bureau. DoH was a longitudinal study aiming to understand the motivations and barriers to clinical trial participation among older African Americans in Atlanta, GA. This study involved a cohort of 221 African Americans recruited from six selected churches in and around the city, and implemented an educational intervention targeting clinical trial participation. Demographic information as well as health-related behaviors and attitudes were collected from these participants at baseline, 3 months, and 12 months post-recruitment. The data of interest for this study was taken from the baseline and 3-month surveys. Data were also collected from the US Census Bureau for the neighborhood-level variables.

The goal of this research was to explore the possibility of using neighborhood-level characteristics as predictors of health-seeking behaviors, specifically influenza vaccination. In order to address the five research questions, the method of analysis was to construct models that used these neighborhood-level variables in conjunction with individual perceptions of the neighborhood, to predict influenza vaccination among elderly African Americans in metro Atlanta.

All data analysis were performed using IBM SPSS statistics, version 22. The first step of analysis was to select the variables of interest from the Dose of Hope dataset and the census data, and to organize these variables into three levels. Level one consisted of neighborhood-level variables taken from census data as well as demographic variables taken from the DoH survey, which consisted of age, sex, percentage of residents of black race, percentage of households without vehicles available, percentage of vacant households, violent crime rates, and the neighborhood deprivation index (NDI).

For observations of descriptive statistics (Table 1), variables were reported as categorized in the DoH dataset. For analyses, age was kept continuous, while the health insurance variable was categorized as ‘Insured’ and ‘Uninsured’, education level as ‘less than high school’ and ‘high school degree and beyond,’ and unemployment as ‘employed’ and ‘unemployed.’ Of concern was keeping the ‘age’ variable continuous since each one-year change in age may not equate to the same effect on vaccination status. A Hosmer-Lemeshow test was conducted to determine if a model with age as continuous provided adequate model fit for the data. All multivariate models containing the age variable were assessed for validity of this linearity assumption. The Box-Tidwell test assessed this by examining the significance of the interaction of the natural log of age and the age variable itself; non-significant interaction terms indicated that the odds ratio for age and vaccination could be interpreted linearly.

Level two consisted of variables predicted to be intermediates in the relationship between these neighborhood and individual characteristics and influenza vaccination; this includes attitudes toward vaccination and perceived neighborhood security, both of which are summary variables equal to the mean score of the responses to the questions measuring the two respective factors, after dropping the items that did not contribute to those factors, as determined by exploratory factor analysis. A higher score for attitudes toward vaccination indicated a more favorable and knowledgeable perception of vaccinations. A higher score for perceived security indicated a more favorable or safe perception of one's neighborhood.

Questions measuring perceived security included the following: (participants provided ratings from 1 to 5, for increasing feelings of safety/security)

1. How safe do you feel in your daily life?
2. Do you feel you are living in a safe and secure environment?
3. How comfortable is the place where you live?
4. How easily are you able to get good medical care?

Statements used to measure attitudes toward vaccination included (participants rated their agreement from 1 to 5):

1. My body can protect itself against diseases.
2. I worry that getting the flu shot would give me the flu.
3. I would be *less likely* to get a flu vaccine if it gave me symptoms such as tiredness or fever.
4. Immunizations can actually lead to illness.
5. I doubt whether vaccines really work.

Neighborhood Deprivation Index

Based on the methods described by Messer, et al., a neighborhood deprivation index (NDI) was constructed using the counties of residence for the participants in the study (30). Residents lived in Clayton, Cobb, Fayette, Fulton, Gwinnett, Henry, Newton, and Rockdale counties, and so the census tracts in these counties were used to construct the index. As described by Messer, et al, the index was developed using principle component analysis where factor loading scores were calculated for each variable in the index and then standardized to a mean of zero and standard deviation of 1 by dividing each factor loading by its eigenvalue (30). Messer et al compiled a list of possible variables from relevant literature, and then used principle component analysis to select variables for the index (30).

The variables Messer, et al, chose for their index were percentage of female headed households with dependents, unemployment rate, percentage of households under the poverty line, percentage of households receiving public assistance, percentage of households with income under $30,000, percentage of crowded households (defined as greater than one person per room), percentage of males in management and professional positions, and percentage of population with less than high school education, all taken from 2000 census data (30). Therefore, these eight variables were chosen for the development of an updated NDI specific to the census tracts in metro Atlanta. Data from the 2012 and 2010 US Census were used to obtain data for each census tract in the nine counties of interest. The income cutoff of under $30,000 was changed to under $35,000 to account for inflation from 2000 to 2012. The standardized index was multiplied by the participant’s values for each of the eight NDI variables, and then summed to create one NDI score. This score was treated as a continuous variable in linear and logistic regression analyses.

Missing Data Imputation

Variables taken from the DoH survey had minimal missing values; age was missing 1% of the data, health insurance status was missing 7%, employment status was missing 4%, and vaccination outcome was missing 6%. There was a large percentage, 23%, of missing data for the violent crime statistics, since they were not available for every census tract of interest. Missing data were imputed using the multiple imputation procedures in SPSS using regression with all level one and two variables including insurance, education, income, and vaccination outcome as predictors. The imputed dataset contained multiple iterations of imputed data for all missing data, including the violent crime rates. Regression analyses were carried out using this imputed dataset, and pooled estimates were reported when available.

Data Analysis and Model Selection

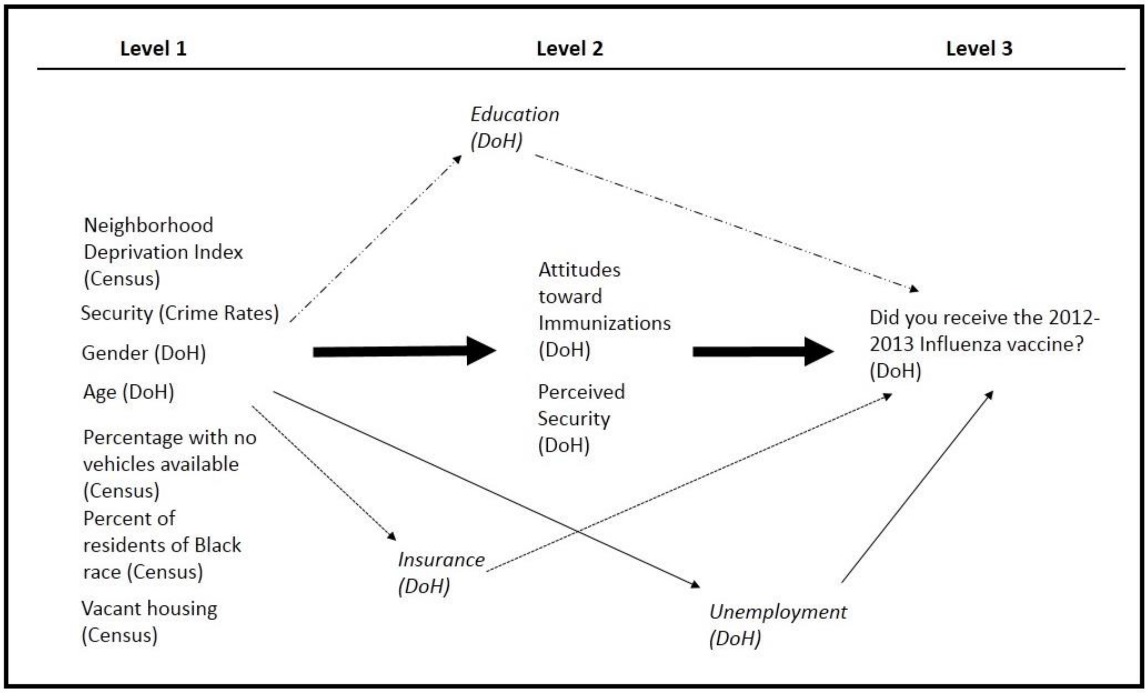
Descriptive statistics were collected for each variable of interest. Correlations between pairs of the predictor variables were calculated. Bivariate analyses for the association of each variable with the outcome of influenza vaccination were calculated. Using the evidence from previous literature, model selection was carried out by selecting variables of interest to be included as predictors of influenza vaccination. In order to understand the relationships between the 3 levels of variables within this small sample size and test the hypothesis that level 1 variables work in conjunction or through level 2 variables to influence level 3, separate models were constructed (Figure 1). The first model used level 1 as predictor of level 3, the second model used levels 1 and 2 as predictors of level 3, the third model used level 1 as a predictor of level 2, and the last model used level 2 as a predictor of level 3. The models with level 3 as an outcome used binary logistic regression while the models with level 2 variables as outcomes used simple linear regression.

The first and second models were assessed one at a time for interaction with the DoH variables insurance status, unemployment, and education; these variables were added as predictors in the model one at a time and two-way interaction terms of each level 1 or 2 variable with these possible effect modifiers were created. Significance of the interaction terms was assessed with an over all likelihood ratio test, and upon evidence of significance, backward elimination procedures were used to determine which individual interaction terms could be dropped from the model.

Random Effects

Because the outcome of influenza vaccination was obtained from the 3-month survey, there was a possibility of an underlying effect of the educational intervention on the self-report of influenza vaccination. Additionally, since assignment to the intervention or control groups was based on the church where the individual was recruited, a mixed model was constructed for the second model (levels 1 and 2 as predictors of influenza vaccination), including a random effect term for the participants' church to account for the possible correlations within these clusters of individuals.

Figure 1. Diagram of Hypothesized Associations between multi-level characteristics and influenza vaccination, Dose of Hope, 2012



Chapter IV

Results

Data Exploration

Table 1 shows the descriptive statistics for each variable of interest before missing data imputation. The average age of participants was 64, and most (78.3%) were female. Most were high school graduates (94%) and most were employed (80%). It should be noted that 38% were retired, and most of the others reporting ‘other’ to employment status were self-reported to be disabled. Because there were 13 people missing influenza vaccination status, they were excluded from preliminary data exploration and bivariate analyses. These were later imputed with the missing violent crime data before multivariate analysis.

For the census-level variables, participants lived in census tracts with a high mean percentage of residents that were black (71.8%), though the percentage varied greatly across census tracts. The percentage of vacant households was on average 15%, and on average 5% of the participant's census tract residents were without vehicles. The census tract violent crime rates averaged 32.2 per 1000 across all participants, however there were 51 observations missing, 23.1% of the study population. For this reason, the missing data were imputed using regression with the other predictor variables of interest before any further analyses were performed.

A mean score for perceived security was calculated by taking the average of the scores of responses for items related to perceived security, after removing an item that was dropped based on a previously completed factor analysis. For the outcome of interest, influenza vaccination, there were 46% vaccinated and 54% unvaccinated. By design, the participants were distributed relatively evenly across the six churches that served as recruitment sites.

Table 1. Descriptive Statistics for Dose of Hope Participants, Atlanta, GA, 2012		
	No	**%**
Demographics		
Sex		
Male	48	21.7%
Female	173	78.3%
Age (missing: 3)		
50-64	114	55.3%
65+	92	44.7%
Health Insurance Status (missing: 15)		
Insured	187	84.6%
Uninsured	19	8.6%
Education		
Less than High School	13	5.9%
High School Graduate and beyond	208	94.1%
Employment (missing 8)		
Employed	176	79.6%
Unemployed	37	16.7%
Receive 2012-2013 Season Flu Shot		
Yes	95	45.7%
No	113	54.3%
Church		
1	41	18.6%
2	29	13.1%
3	39	17.6%
4	37	16.7%
5	31	14.0%
6	44	19.9%
	(mean)	**[std dev]**
Neighborhood-level Characteristics		
Percentage of residents of black race **(missing: 4)**	(71.8)	[26.7]
Percent of vacant houses (missing: 3)	(14.6)	[9.0]
Percent without vehicles available (missing: 17)	(4.5)	[5.3]
Violent Crime Rates (missing: 51)*	(32.2)	[27.4]
Perceived Security Mean Score (missing: 4)	(4.0)	[0.8]
Attitudes about Vaccinations Mean Score (missing: 10)	(3.0)	[0.9]

*Crime Rates were only available for select census tracts. Multiple Imputation of missing data based on associations with the other variables of interest was used to generate adequate data for analysis.

Bivariate Analyses

The association between each predictor variable of interest and influenza vaccination was examined before data imputation (Table 2). Statistical significance was found in the relationships of dichotomized age [OR=2.4, $p<0.01$], health insurance status [OR=17.8, $p<0.01$], and attitudes toward vaccinations [OR=4.3, $p<0.01$] with influenza vaccination. The bivariate association between continuous age and vaccination was also significant [OR=1.07, $p<0.01$], and had good fit according to the Hosmer-Lemeshow test [$p=0.76$]. The Box-Tidwell test supported this because all interaction terms of age and the natural log of age were non-significant in all multivariate models, confirming the validity of the treatment of age as continuous in these models. The other variables of interest were not found to be statistically significantly associated with influenza vaccination in the absence of other covariates.

Table 2. Bivariate Analysis, Distribution of Descriptive Variables by Vaccination Outcome, Dose of Hope, Atlanta, GA, 2012						
	Did you get the flu vaccine?			% vaccinated		
	Yes	No	Total			
	95	113	208	45.67		
Descriptive Variables					OR (95% CI)	*P* value
Sex						
Male (ref)	20	25	45	44.4	--	--
Female	75	88	163	46.0	1.06 (0.55, 2.07)	0.99
Age						
50-64 (ref)	41	73	114	36.0	--	--
65+	53	39	92	57.6	2.42 (1.38, 4.25)	<0.01
Health Insurance Status						
Uninsured (ref)	1	18	19	5.3	--	--
Insured	92	93	185	49.7	17.81 (2.33, 136.15)	<0.01
Education						
Less that High School (ref)	5	6	11	45.5	--	--
High School Graduate and Beyond	90	107	197	45.7	1.01(0.30, 3.42)	1.00
Employment						
Employed (full time, part time) (ref)	70	72	142	49.3	--	--
Unemployed/retired/disabled	23	36	59	39.0	1.52 (0.82, 2.82)	0.21
Church						
1 (ref)	20	18	38	52.6	--	<0.01 (overall)
2	17	11	28	60.7		
3	11	27	38	28.9		
4	22	12	34	64.7		
5	14	16	30	46.7		
6	11	29	40	27.5		
Percentage of residents of black race					1.00 (0.99, 1.01)	0.62
Percent of vacant houses					1.01 (0.98, 1.04)	0.63
Percent without vehicles available					1.03 (0.97, 1.09)	0.31
Violent Crime Rates					1.00 (0.99, 1.01)	0.70
NDI					1.00 (1.00, 1.00)	0.28
Perceived Security Mean Score					0.91 (0.64, 1.30)	0.61
Attitudes about Vaccinations Mean Score					4.31 (2.74, 6.78)	<0.01

*Significant at the α= 0.05 level when controlling for other variables in the model

Predictive Models

The first model assessing the association between level one variables and influenza vaccination is displayed in Table 3. This model explains the association between each variable while controlling for all other level one variables. Age was inversely/positively significantly associated with influenza vaccination [OR=1.07, $p<0.01$].

The second model used levels one and two variables regressed on level 3. Statistical significance was found for age [OR=1.06, p=0.02], percentage of population without vehicles available [OR=1.08, p=0.07], and the mean score for attitudes toward vaccinations [OR=5.37, $p<0.01$].

The third model of the associations of level 2 variables with influenza vaccination shows positive associations between both perceived security [OR=0.61, p=0.03] and attitudes toward vaccination [OR=4.90, $p<0.01$].

The fourth models contained level one variables with level 2 variables as outcomes. The percentage of the population without vehicles available was statistically significantly associated with perceived security [OR= 0.05, p=0.03], and age was statistically significantly associated with attitudes toward vaccinations [OR= 0.04, p=0.01].

Table 3. Models of Influenza Vaccination with Neighborhood and Individual Effects, Dose of Hope, Atlanta, GA, 2012			
Model	Predictors	Outcome	*P* value
1.			
	Neighborhood deprivation index	Receive the 2012-2013 influenza vaccine? (Y/N)	0.30
	Crime statistics		0.79
	sex		0.60
	age		<0.01*
	Percent without vehicles available		0.22
	Percentage of residents of black race		0.31
	Percent of vacant houses		0.79
2.			
	Neighborhood deprivation index		0.47
	Crime statistics		0.84
	sex		0.68
	age		0.02*
	Percent without vehicles available	Receive the 2012-2013 influenza vaccine? (Y/N)	0.07
	Percentage of residents of black race		0.28
	Percent of vacant houses		0.65
	Mean of Security Questions		0.05
	Mean of Attitudes toward Immunizations		<0.01*
3.			
	Mean of Security Variables	Receive the 2012-2013 influenza vaccine?	0.03*
	Mean of Attitudes toward immunizations		0.00*
4.			
	Neighborhood deprivation index		0.57
	Crime statistics		0.95
	sex	Perceived Security (Mean Score)	0.85
	age		0.11
	Percent without vehicles available		0.03*
	Percentage of residents of black race		0.26
	Percent of vacant houses		0.48
5.	Neighborhood deprivation index		0.38
	Crime statistics		0.74
	sex	Attitudes toward Immunizations (Mean Score)	0.66
	age		0.01*
	Percent without vehicles available		0.08
	Percentage of residents of black race		0.76
	Percent of vacant houses		0.26

*The association of this variable with the outcome is significant at the α=0.05, controlling for the other variables in the model

Interaction Assessment

It was hypothesized that the effect of the selected neighborhood-level and demographic characteristics differed among those insured compared to those who were uninsured. The binary insurance variable was used to create interaction terms of each predictor in level one with insurance status. A likelihood ratio test comparing the full model with level one variables plus insurance and all possible two-way interaction terms of insurance with the other covariates, and the reduced model, containing only level one variables and insurance, yielded a non-significant result.

Assessing if the association differed among those employed vs. unemployed yielded a non-significant result as well. It was also hypothesized that the effect of level one variables on influenza vaccination would differ by education level, and this was examined through a likelihood ratio test of the model with level one variables regressed on the influenza vaccination outcome; this test yielded a non-significant p-value.

Random Effects

Models with the random effect of the 'church' variable were constructed for models with receiving the flu shot as an outcome. Age was significant in a model controlling for all other level 1 variables with an outcome of influenza vaccination. A mixed model for model 2 also showed only age and attitudes toward vaccination as significant; perceived security was no longer significant when controlling for the other variables.

Table 4. Multivariate Mixed Models for Influenza Vaccination, Atlanta, GA, Dose of Hope, 2012			
Model	Predictors	Outcome	*P* value
1.			
Fixed Effects	Neighborhood deprivation index		0.34
	Crime statistics		0.76
	sex		0.31
	age	Receive the 2012-2013 influenza vaccine? (Y/N)	0.01*
	Percent without vehicles available		0.37
	Percentage of residents of black race		0.31
	Percent of vacant houses		0.81
Random Effect	Church		
2.			
Fixed Effects	Neighborhood deprivation index		0.47
	Crime statistics		0.88
	sex		0.61
	age		0.04*
	Percent without vehicles available	Receive the 2012-2013 influenza vaccine? (Y/N)	0.07
	Percentage of residents of black race		0.29
	Percent of vacant houses		0.56
	Mean of Security Questions		0.06
	Mean of Attitudes toward Immunizations		<0.01*
Random Effect	Church		

*Significant at the α= 0.05 level when controlling for other variables in the model

Chapter V

Discussion

The analysis of neighborhood-level and individual factors and their effect on vaccination decisions was examined. Separating the variables into levels allowed for the analysis of these neighborhood-level factors with the vaccination outcome through other individual-level variables possibly related to flu vaccination.

Although none of the models with vaccination as an outcome showed significance for all covariates, some interesting relationships have been described. In the first model, age was significantly associated with receiving the flu vaccine, even when controlling for sex as well as the neighborhood-level factors. The odds of getting the flu shot was estimated to increase by 1.07 for every one year increase in age.

In the second model that adds attitudes toward vaccinations and perceived security, age is again significant as well as these two added variables, while all other variables still show very high p-values. It is interesting that even while controlling for attitudes toward vaccinations and security along with the other variables from model 1, age is still significantly associated with vaccination, with the odds ratio increasing by 1.06 for every one year increase in age; this result has also been shown in previous studies (22). Although the study population was restricted to those over 50, it appears that being older has some relationship with health-seeking behavior; this could be due to family member influence, forms of social support, or some other difference in healthcare attitudes or access that was not captured in the survey.

It is noteworthy that a strong relationship is seen between attitudes toward vaccinations and actual vaccination as shown in model three. Odds of vaccination increases 5.1 times for every one unit increase in positive attitudes toward vaccination, as measured by the DoH survey.

Perceived security was also significant when controlling for attitudes, though the odds of vaccination decreased by 0.61 with increasing feelings of safety, an opposite relationship than what was hypothesized based on previous literature (29). An explanation for this result is that in older populations, individuals may rely on Medicare, which covers preventive services such as influenza vaccinations. In order to understand this relationship, a model was constructed containing perceived security, insurance status, and vaccine hesitancy, though the estimate for perceived security still showed the same association. Lowering costs for preventive services could make this group more likely to receive the vaccine than those who are not eligible for these services. Previous studies have found significant associations with security and safety of the vaccination location, and not the individual's place of residence. In this population, it is possible that the perceived security of the neighborhood does not match the perceived security of the hospital or clinic, and therefore has no effect. Also, this study population was recruited from faith-based settings, meaning all participants are willing to travel to their places of worship regularly, suggesting that feelings of safety and security may have less influence on behavior in this population than others.

The percentage of vehicles available, a proxy for neighborhood affluence and ease of transportation, was significantly associated with perceived security, when controlling for all other variables. Because perceived security is then significantly associated with receipt of the vaccine, adjusting for vaccination attitudes, a possible pathway by which area-level variables influence individual characteristics and behaviors has been discovered.

Bivariate analysis of perceived security alone with influenza vaccination yielded a non-significant result, confirming that attitudes toward vaccination is a confounder in this relationship and must be controlled for in order to understand the effect that perceived safety and security have on health-seeking behavior. Both of these factors were associated with other demographic factors, as shown by model 4.

Model analysis including the church of attendance as a random effect for model 2 showed that the effect of the intervention on the outcome of influenza vaccination was not very influential, since similar results were observed in terms of significance of covariates when church was included in the model. This could be because the receipt of the vaccination occurred before the study began, and so the intervention was not able to influence their behavior or response to the question.

Strengths and Limitations

This analysis provides a unique perspective of aspects that influence influenza vaccination, and employs the use of neighborhood-level variables to understand mechanisms behind the decisions to receive the vaccine or not, factors that previously had not been fully explored in relation to vaccination decisions. Restricting the population to only African Americans eliminated confounding related to race, and allows for an analysis of these covariates in a single population.

There were a few limitations; the power of this study was limited by its sample size. With only 221 participants in a racially homogenous population, significant differences due to covariates could be difficult to ascertain. Despite this apparent limitation, any significance that was able to be seen due to covariates such as age suggest a very relevant association that may be even more apparent outside this homogenous population.

The study design provided some limitations, in that the data were mostly self-reported. Validity is contingent on the honesty and accuracy of the participants in reporting their demographic and other characteristics, including their influenza vaccination status. It is possible that there would be some social desirability bias due to participants reporting that they had received the influenza vaccination, when they had not, in order to appear more concerned about healthy behaviors. The hope is that the anonymous survey allowed participants to feel the freedom to be honest about their health behavior, however a better method would be to utilize electronic medical records for determination of vaccination status, provided that most vaccinations were administered by physicians and not outside clinics (9).

Selection of the participants was based on attendance of a church. Although a large proportion of elderly African Americans attend churches, the sample for this study may not have been representative of the African American population in Atlanta. The cross-sectional design of this study does not allow for causal pathways to be drawn since temporality was not explicitly measured. It is hypothesized that the individual and neighborhood-level characteristics are predictors of influenza vaccination, however this study design does not permit confirmation of this hypothesis.

For this specific analysis, it was assumed that the neighborhood-level factors represented a summary of the participants' individual factors and therefore explained individual vaccination behaviors. Because this study sample was of a very specific race and culture, it is possible that these neighborhood-level factors were not simply an aggregate of these individuals' characteristics but were influenced by the other individuals residing in the same census tract who had different characteristics but whose vaccination decisions were not measured.

The models that were constructed may not have included all possible confounders or interactions that can explain vaccination decisions. One factor that was not considered was status quo bias; those who have previously received vaccinations will continue to get vaccinations in the future (22). Other analyses of this study data showed a high correlation between a family member receiving a flu vaccine and the decision to be vaccinated. Although these factors were not the focus of this study, including them in the model would help to elucidate how much of the decision to vaccinate is due to the area-level variables alone.

Even so, analyzing this specific population provided insight into some of the barriers that could occur when making health-related decisions, and provided a basis for future health policy. Interventions to increase vaccination coverage among this highly under-vaccinated population must not only attempt to increase access to care, but also include education to increase trust of vaccinations, as well as somehow overcome or consider neighborhood-level factors such as security and poverty.

Conclusions

These analyses shed some light on the ways that neighborhood and individual-level factors can work in conjunction to influence vaccination decisions. It was found that building a model of factors that influence influenza vaccination decisions should include age and perceived security of the environment, as well as other neighborhood-level factors that may be associated with these variables. Analyses such as these can be used to inform public health policy and population-level interventions. When designing interventions a focus needs to be made on not only access to care for specific populations, but also on the relationship between environmental or neighborhood-level factors on health attitudes, and how these attitudes influence health decisions. The results of this analysis can be applied to most elderly African Americans in the Atlanta area, however further study will need to be done in order to understand motivations for health behaviors among different races and locations.

Public Health Implications

Understanding the mechanisms behind human health behaviors is essential for creating interventions that can be tailored to the specific population of interest. In the case of vaccination coverage among older African Americans, it is important to look at all factors that could serve as barriers or motivators to receiving vaccines. When studying motivations of health behaviors among African Americans especially, the focus is often on individual access to care and trust of the provider. Although these factors play a role in health behaviors and decisions, there are often outside factors that must be considered as well. Neighborhood safety, security, socioeconomic status, and transportation availability are all important factors that could influence health behaviors. Understanding how these neighborhood factors influence individual perceptions and in turn, decisions, allows for a more specific intervention or public policy that can help to circumvent these issues. For example, providing vaccinations at a location near the home could mitigate the effects of high crime-ridden areas, or low vehicle availability. In this way, the success of public health interventions will be optimized, as they aim to target all barriers and limitation of those in need of vaccinations.

Future Directions

This study explored the use of neighborhood-level characteristics on self-reported vaccinations. Future research will need to be done to better understand the effects of these characteristics, especially in older African American populations. A future aim would be to increase the study population first to include a larger sample size that is representative of the elderly African American population in Atlanta as a whole, and then to include a variety of races, in order to determine if these neighborhood-level variables have different effects across races or regions. More of these neighborhood-level characteristics could be explored, and a deprivation index that is tailored specifically to vaccination decisions, according to previous literature, would be developed. A case-control study with individuals recruited on vaccination outcome can be used to compare these characteristics among those who did and did not get the vaccine. Once the relevant characteristics predicting vaccination outcomes have been identified, a randomized control trial can be designed to examine the feasibility of implementing an intervention addressing these factors.

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