The mediating effects of barriers to vaccination on the relationship between race/ethnicity and influenza vaccination status in a rural Southeastern Louisiana medical center

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Summary

Introduction. *Persistent disparities in influenza vaccination rates exist between racial/ethnic minorities and Whites. The mechanisms that define this relationship are under-researched.*
Methods. *Surveys assessing barriers to vaccination were administered to outpatients in a rural medical center in Southeastern Louisiana. Survey responses were matched to patient medical records. Likert-style statements were used to measure barriers to vaccination. A mediation analysis assessing the relationship between race and influenza vaccination mediated by vaccination barriers was conducted.*
Results. *The self-reported influenza vaccination rate in those surveyed was 40.4%. Whites (45.5%) were more likely than racial/ethnic minorities (36.3%) to report receipt of an influenza vaccination (p = 0.02). Racial/ethnic minorities reported*

significantly higher vaccination barrier scores (p < 0.01). The relationship between race/ethnicity and vaccination was mediated by vaccination barriers, when controlling for provider recommendation and having at least one comorbid medical condition (natural indirect effect [NIE] p-value = 0.02, proportion mediated = 0.71).
Conclusions. *Barriers to vaccination mediates the relationship between race/ethnicity and vaccination status. Providers should focus on minimizing fears that the vaccine will cause illness and emphasize that the vaccine is safe and effective at preventing severe influenza-associated illness. Additional efforts should be made to improve accessibility of the influenza vaccine, including addressing costs of vaccination and expanding the number and types of settings where the vaccine is offered.*

Introduction

The influenza virus infects 5-20% of the United States (US) population, resulting in an estimated 200,000 hospitalizations and between 3,000 and 49,000 deaths each influenza season [1-3]. Receiving the annual influenza vaccine offers significant protection against severe sequelae of influenza infection. Influenza vaccination prevented an estimated 1.6-6.7 million illnesses, 790,000-3.1 million outpatient medical visits, 39,000-87,000 hospitalizations, and 3,000-10,000 respiratory and circulatory deaths from the 2010-11 through the 2015-16 influenza seasons in the US alone [4]. However, despite the tremendous health burden caused by seasonal influenza and the large health and economic burden that could be mitigated by annual vaccination, vaccination rates have remained low in the general population, with annual influenza vaccination uptake among US adults fluctuating between 38.8-43.6% from the 2009-10 through the 2016-17 influenza seasons [5].
When rates of annual influenza vaccination are stratified by race/ethnicity, it becomes clear that racial/

ethnic disparities are consistently present in influenza vaccination. White adults aged 18 years and older (45.9% vaccination uptake) were more likely than non-Hispanic Black adults (37.4%) and Hispanics (36.9%) to receive the influenza vaccination during the 2016-17 influenza season [5]. Similar differences in influenza vaccination among different races have been documented in previous flu seasons [6-9].
There are many factors that contribute to the persistent racial/ethnic disparities in influenza vaccination. Potential barriers to influenza vaccination fall into one of three categories: (1) demographic, socioeconomic, and health-related factors, (2) negative attitudes and beliefs toward vaccination, and (3) healthcare access barriers to vaccination [10-16].
Various demographic, socioeconomic and health-related factors have been identified in the literature as potentially influential on vaccination status, including education status, employment, income, age, insurance status, having regular preventive care, having medical conditions that increase the risk of influenza-associated morbidity and mortality, receiving a provider recommendation, and others [10-14, 17-21].

Negative attitudes and beliefs include a misunderstanding of the importance of the influenza vaccine, an underestimation of personal risk, doubts about the vaccine efficacy, the belief that the influenza vaccine will cause influenza-associated illness or that the influenza vaccine is unsafe, among others [12, 16, 22]. These beliefs have been demonstrated in higher proportions in racial/ethnic minorities [12, 16, 22].

Healthcare access refers to the ability of the patient to obtain an influenza vaccine, including the ability to afford the influenza vaccine and the ability to reach a location offering the influenza vaccine (16). Racial/ethnic minorities remain disproportionately under or uninsured [23]. The lack of insurance increases the out of pocket cost of immunizations, potentially reducing vaccination uptake among racial/ethnic minorities [24]. Additionally, some individuals may find it difficult to get to locations that offer immunizations. This would present another barrier to vaccination, particularly among persons who live in rural areas [16].

Each of these factors has been studied independently. However, the underlying mechanisms that relate these factors are under-researched [25-27]. This study attempts to account for the multifactorial and complex relationship between these differing factors in an attempt to explain the mechanisms by which an individual's influenza vaccination behavior is defined. Specifically, we propose that negative attitudes and beliefs toward and healthcare access barriers to influenza vaccination mediate the relationship between race/ethnicity and influenza vaccination.

As such, this study has two objectives. First, we will establish that disparities in influenza exist in our patient population. Second, we will assess the mediating effects of negative attitudes and beliefs toward and healthcare access barriers to influenza vaccination on the relationship between race/ethnicity and influenza vaccination.

Methods

STUDY DESIGN AND SETTING

This study combined a cross-sectional survey with retrospective data linkage through the Louisiana State University Health Care Services Division (HCSD) Epic electronic health record (EHR) database. This study was conducted among a convenience sample of patients aged 18 years and older seeking care at Lallie Kemp Regional Medical Center (LKRMC) outpatient clinics between May 23rd, 2017 and September 1st, 2017. LKRMC is a federally designated critical access hospital, with a maximum capacity of 25 acute care beds. It is located in Independence, LA (2018 population: 1,902) and serves a rural population that is primarily racial/ethnic minority and low-income (28). LKRMC provides 24-hour emergency care and is available to anyone, regardless of an individual's ability to pay. LKRMC has approximately 35,000 visits per year in designated outpatient clinics.

SURVEY DEVELOPMENT

The survey used in this study was designed to capture information regarding attitudes and beliefs with respect to the annual influenza vaccine and healthcare access barriers to the receipt of the influenza vaccine. More specifically, the survey was designed to examine the barriers, both of perception and reality, to the receipt of the influenza vaccination. These potential barriers to vaccination were identified through a search of the literature surrounding influenza vaccination and converted into 5-item Likert-style statements assessing how strongly each individual experienced barriers to vaccination [10, 12, 15-22, 26, 29-35].

The initial questionnaire was screened by HCSD physicians and Louisiana State University Health Science Center (LSUHSC) investigators to ensure that the question construct accurately reflected the vaccination barrier it was designed to represent, that the questions would be easily understood by patients seeking care at LKRMC, and that the questionnaire would be of an appropriate length to incorporate into the clinic flow at LKRMC. An initial pilot of the questionnaire was then implemented in LKRMC outpatient clinics. Twenty patients were surveyed and asked questions to ascertain whether the Likert measures accurately measured barriers to influenza vaccination. As a result of the pilot questionnaire, the 5-item Likert scale was collapsed to a 3-item Likert scale and the wording of several statements was adjusted. The 5-item statements were confusing to the patients and several of the questions required more specificity.

The final ten 3-item Likert statements (Tab. I) allowed responses of "disagree," "no opinion," and "agree" and eliminated possible "strongly disagree" and "strongly agree" responses. Three of the final statements, "the flu shot is too expensive," "it is too much effort to get the flu shot," and "it is difficult to get to a location that offers the flu shot" related specifically to healthcare access barriers to influenza vaccination. Seven of the final statements, "your personal or religious beliefs prevent

Tab. I. Likert statements used in the questionnaire administered among outpatients in Lallie Kemp Regional Medical Center from May 2017-September 2017.

Healthcare Access Barriers
The flu shot is too expensive
It is too much effort to get the flu shot
It is difficult to get to a location that offers the flu shot
Attitudes and Beliefs
Your personal or religious beliefs prevent you from receiving the flu shot
The flu shot is safe*
The flu shot works*
You are unlikely to get the flu even if you do not get a flu shot
If you already had the flu, you do not need to get a flu shot
The flu shot will give you the flu
You need to get the flu shot every year to prevent the flu*

*Reverse coded

you from receiving the flu shot," "the flu shot is safe," "the flu shot works," "you are unlikely to get the flu even if you do not get a flu shot," "if you already had the flu shot you do not need to get a flu shot," "the flu shot will give you the flu," and you need to get the flu shot every year to prevent the flu," related specifically to attitudes and beliefs regarding the flu shot.

The final questionnaire was screened by HCSD physicians and LSUHSC investigators and re-piloted among twenty patients seeking care at LKRMC. Based on the feedback of investigators, physicians, and patients, the second version of the survey was accepted and used as the survey for the study.

In addition to the assessment of vaccination barriers, information regarding patient influenza vaccination status, socioeconomic indicators, including income and employment, and health-related factors such as primary care access and receipt of a provider recommendation, were also collected using the patient survey. Surveys were linked to patient's medical records using a medical record number (MRN) match. Information regarding patient demographics, including race, age, and sex, insurance status, and comorbid conditions considered to be high risk for influenza-associated morbidity and mortality was captured from the EHR.

Data Collection

Data collection began on May 23rd, 2017 and extended through September 1st, 2017. Nurses informed patients upon check-in to LKRMC outpatient clinics that members of the LSUHSC staff would be contacting them at some point during their visit to complete a brief survey. Patients were recruited after the LKRMC medical assistants took the patient's vital signs, but before they were called into a patient room by a nurse. This was identified as the point in the patient visit where a survey would be able to be completed without disrupting the clinic workflow at LKRMC. Patients were asked to sign an informed consent and Health Insurance Portability and Accountability Act (HIPAA) authorization forms, allowing investigators to record survey responses, access medical records, and use that information for analysis and publication.

LSUHSC investigators administered surveys orally and in-person to patients. This process alleviated concerns of illiteracy and misclassified or incomplete answers. Upon check-in to the outpatient clinics, each patient was given an identification bracelet which contained their MRN. LSUHSC investigators used these bracelets to gather the patient MRN, which was recorded into a Research Electronic Data Capture (REDCap) database, a secure online web application for building surveys and managing databases [36]. To ensure accuracy, investigators were required to enter the MRN twice. Matching MRNs allowed investigators to proceed with the interview, while inconsistent MRNs forced investigators to reenter the MRN. Patients were provided with a card detailing the available responses for visual representation of the questions. All responses were given verbally by patients

and entered by LSUHSC investigators into the study database.

Upon completion of data collection, a dataset containing all survey responses, patient information, and unique MRNs was sent to HCSD for linkage with information of interest abstracted from patient EHR records. Data regarding age, height, weight, gender, pregnancy status, race, chronic conditions that increase the risk of influenza-associated morbidity and mortality, (asthma, diabetes, HIV/AIDS, chronic obstructive pulmonary disorder (COPD), heart disease, blood disorders, kidney disease, liver disease), and insurance status were requested for linkage. After this linkage was completed, the dataset was stripped of identifying information, including the MRN, and returned to LSUHSC investigators for analysis. In doing so, investigators minimized the risk of identification through medical information.

Variables

The primary outcome of interest was influenza vaccination status during the 2016-17 influenza season. Information regarding the outcome was collected from self-reported responses. Participants were asked whether they received their flu shot during last year's flu season and were allowed to respond "yes," "no," or "don't remember." Those who replied, "don't remember" (n = 9) were excluded from analysis. Self-reported responses were used because patient medical records only captured influenza vaccination administered within LKRMC and did not account for vaccinations administered at other locations such as workplaces, stores, or retail pharmacies.

The exposure of interest for the study was race/ethnicity. The patient population of LKRMC is comprised primarily of Black and White patients, including few Hispanics and other races and ethnicities, which mirrors the general demographic composition of Louisiana. Therefore, race/ethnicity was dichotomized into a White and racial/ethnic minority (non-White race or Hispanic ethnicity) categories.

The mediator of interest was barriers to vaccination. Barriers to vaccination is a composite continuous variable formed from the 3-item Likert-style statements regarding attitudes and beliefs toward and healthcare access barriers to influenza vaccination. Responses were coded 1-3, with higher numbers indicating increased barriers to vaccination. The coded responses were summed, creating a scale ranging from 10-30, with higher numbers representing increased barriers. Seven of the statements tracked factors that inhibit influenza vaccination and were coded with disagree= 1, no opinion = 2, and agree = 3, while the remaining three (the flu shot is safe, the flu shot works, and you need to get the flu shot every year to prevent the flu) tracked factors that promote influenza vaccination and were reverse coded with agree = 1, no opinion = 2, and disagree = 3. A small portion of the study population had missing values for one (n = 10) or two (n = 1) of the Likert statements. In this case, available responses were summed, divided by the number of available questions, and then rounded

to the nearest whole number. This whole number was then inserted for the missing value.

Potential confounders were captured using both the survey tool and medical records and fell into three categories, demographics, socioeconomic indicators and health-related factors. Demographic variables included age and sex. Age was categorized based on age groups used by the Centers for Disease Control and Prevention (CDC) to report influenza-associated data, those aged 18-49 years, aged 50-64 years, and aged 65 years and older. Sex was categorized as male or female.

Socioeconomic variables included employment, education, and income. Employment was categorized as full/part time, retired, and disabled, unemployed, student, or other. Education was categorized as did not graduate high school, high school graduate/GED recipient, or attended/graduated college.

Health indicators included insurance status, having one or more comorbid conditions considered to be at high risk for influenza-associated morbidity and mortality, having regular preventive care, and receipt of a recommendation to receive the influenza vaccination from a provider. Insurance status was categorized as insured and uninsured. Conditions at elevated risk for influenza-associated morbidity and mortality available in the Epic database were asthma, diabetes, HIV/AIDS, chronic obstructive pulmonary disorder (COPD), heart disease, blood disorders, kidney disease, liver disease [36]. Those with at least one of these conditions in their medical records were considered to have at least one comorbid condition. To classify regular preventive care, patients were asked if they had somewhere they typically receive preventive care services. If a patient stated that they did have a place where they received preventive care services, they were considered to have access to regular preventive care. To assess provider recommendation, patients were asked whether they had received a recommendation to receive the influenza vaccination from a provider during the previous year's influenza season. If the participant replied that they received a recommendation from a provider, then they were considered to have received a provider recommendation. If the participant replied that they did not receive a recommendation, did not see a doctor during that time, or did not remember, then they were considered to not have received a recommendation from a provider, resulting in a dichotomous categorical variable.

STATISTICAL ANALYSIS

Unadjusted relationships between potential confounders, the mediator, and vaccination status were examined using chi-squared tests for categorical variables and t-tests for continuous variables. Barriers to vaccination, the potential mediator of interest, was assessed in a unadjusted model analyzing the relationship between race/ethnicity and vaccination status using the SAS macro established by Valeri and VanderWeele [38].

A full model with all confounders, the mediator, the exposure, and the outcome was created to assess effects of barriers to vaccination on the relationship between race/ethnicity and influenza vaccination status. Exposure-mediator interaction was tested. No interaction was identified. Initially, a log-linear model was attempted. However, the log-linear model failed to converge. Therefore, a Poisson model with more robust standard error was substituted. Backwards elimination was used to establish a final model by eliminating confounders that did not demonstrate significance in the model (p≤0.05) one-by-one until all remaining factors were significant. The final model ultimately included provider recommendation and the presence of at least one comorbid condition (as confounders), race/ethnicity (exposure), vaccination status (outcome), and barriers to vaccination (mediator). Parameter estimates for the unadjusted and adjusted models were obtained.

Results

A total of 703 individuals were approached in LKRMC outpatient clinics, of whom 623 were consented and completed interviews. Five of those who completed interviews were excluded because they were not found in the Epic database (n = 2) or they were called into their appointment prior to completion of the interview (n = 3). Nine individuals who reported not remembering their vaccination status were also excluded. This left a final sample of 609, yielding a final response rate of (86.6%). 40.4% of the final sample had received an influenza vaccination (Tab. II). White patients (45.5%) were more likely than racial/ethnic minority patients (36.3%) to have received an influenza vaccination (p = 0.02). Those of older age groups (p < 0.01), who were employed full or part time or retired (p = 0.01), and had incomes above the Louisiana poverty level (p = 0.03) were all more likely to receive influenza vaccination than their respective reference groups. Those who received a doctor's recommendation (p < 0.01), had access to preventive care (p < 0.01), and who reported having at least one comorbid condition were more likely to receive the influenza vaccination than those without (p < 0.01). Other factors showed no unadjusted association with influenza vaccination status.

The mean vaccination barrier score in the population was 15.2 (SD = 3.6) (Tab. III). Those who were unvaccinated (mean = 16.7, SD = 3.3) reported significantly higher barriers to vaccination than those who were vaccinated (mean = 12.8, SD = 2.7) (p < 0.01). Additionally, racial/ethnic minorities (mean = 15.5, SD = 3.5) reported higher levels of barriers to vaccination than Whites (mean = 14.8, SD = 3.6) (p = 0.01).

The unadjusted model assessing the mediating effects of barriers to vaccination demonstrated significant mediation of the relationship between race/ethnicity and vaccination status (NIE p-value = 0.01, proportion mediated = 0.69) (Tab. IV). In the final, adjusted model

Tab. II. Characteristics of the patients seeking care at Lallie Kemp Regional Medical Center by influenza vaccination status, May 2017- September 2017 (n = 609).

Patient Characteristics	Study Sample n = 609 (%)	Unvaccinated n = 363 (%)	Vaccinated n = 246 (%)	P-Value*
Outcome				
Vaccination Status				
Vaccinated	246 (40.4)	N/A	N/A	N/A
Unvaccinated	363 (59.6)			
Demographics				
Race				
White	266 (43.8)	145 (54.5)	121 (45.5)	**0.02**
Racial/Ethnic Minority	342 (56.2)	218 (63.7)	124 (36.3)	
Age				
Aged 18-49 Years	219 (36.0)	157 (71.7)	62 (28.3)	**< 0.01**
Aged 50-64 Years	279 (45.8)	153 (54.8)	126 (45.2)	
Aged 65 Years and Older	111 (18.2)	53 (47.8)	58 (52.2)	
Sex				
Male	226 (37.2)	146 (64.6)	80 (35.4)	0.06
Female	382 (62.8)	217 (56.8)	165 (43.2)	
Socioeconomic Indicators				
Education				
Did not Graduate High School	173 (28.4)	99 (57.2)	74 (42.8)	0.75
High School Graduate	265 (43.5)	160 (60.4)	105 (39.6)	
Attended/Graduated College	171 (28.1)	104 (60.8)	67 (39.2)	
Employment				
Full/Part Time	228 (37.5)	154 (67.5)	74 (32.5)	**0.01**
Retired	96 (15.8)	53 (55.2)	43 (44.8)	
Unemployed/Disabled/Student/Other	284 (46.7)	155 (54.6)	129 (45.4)	
Income				
Above Poverty Level	127 (21.0)	86 (67.7)	41 (32.3)	**0.03**
Below Poverty Level	478 (79.0)	274 (57.3)	204 (42.7)	
Health-Related Factors				
Insurance				
Insured	492 (80.9)	285 (57.9)	207 (42.1)	0.06
Uninsured	116 (19.1)	78 (67.2)	38 (32.8)	
Doctor's Recommendation				
Recommended Vaccine	368 (60.7)	163 (44.3)	205 (55.7)	**< 0.01**
Not Recommended Vaccine	238 (39.3)	197 (82.8)	41 (17.2)	
Preventive Care Access				
Has Preventive Care Access	515 (84.6)	287 (55.7)	228 (44.3)	**<0 .01**
No Preventive Care Access	94 (15.4)	76 (80.9)	18 (19.1)	
Has at Least One Comorbid Condition				
Yes	303 (49.8)	149 (49.2)	154 (50.8)	**< 0.01**
No	306 (50.3)	214 (69.9)	92 (30.1)	

n = population.
Bolded values are significant at p ≤ 0.05.
*p-value calculated using chi-squared tests.

only provider recommendation (p < 0.01) and having at least one comorbid condition (p= 0.04) remained predictors of vaccination status. The relationship between race/ethnicity and influenza vaccination status also proved to be mediated by barriers to vaccination (NIE p-value = 0.02, proportion mediated = 0.71). However, both the direct (p = 0.68) and the total (p = 0.16) effects of the adjusted model were non-significant.

Discussion

The objectives of this study were (1) to evaluate racial/ethnic disparities in influenza vaccination and (2) to assess the mediating effects of barriers to influenza vaccination on the relationship between race/ethnicity and receipt of influenza vaccination. We determined that there was a relationship between race/ethnicity and influenza vaccination status, where racial/ethnic

Tab. III. Vaccination barrier score by influenza vaccination status and race/ethnicity among patients seeking care at Lallie Kemp Regional Medical Center, May 2017-September, 2017 (n = 609)

Mediator by Outcome and Exposure	Vaccination Barriers Score (Mean (SD))	P-Value*
Overall	15.2 (3.6)	N/A
Outcome		
Vaccination Status		
Unvaccinated	16.7 (3.3)	**< 0.01**
Vaccinated	12.8 (2.7)	
Exposure		
*Race**		
White	14.8 (3.6)	**0.01**
Racial/Ethnic Minority	15.5 (3.5)	

S= standard deviation.
Bolded values are significant at p≤0.05.
*p-value calculated using t-tests.
**There is one person missing data on race/ethnicity.

Tab. IV. Assessment of the relationship between race/ethnicity and influenza vaccination status, mediated by barriers to vaccination (n = 605*)

Effect	Unadjusted** Model		Adjusted Model***	
	p-value	Estimate (95% CI)	p-value	Estimate (95% CI)
Direct Effect	0.59	0.93 (0.73, 1.20)	0.68	0.95 (0.74, 1.22)
Indirect Effect	**0.01**	0.84 (0.73, 0.96)	**0.02**	0.87 (0.77, 0.98)
Total Effect	0.09	0.78 (0.59, 1.04)	0.16	0.82 (0.62, 1.08)
Proportion Mediated	0.69		0.71	

CI = confidence interval.
Bolded values are significant at p ≤ 0.05.
*Four individuals had missing data (3 on provider recommendation and 1 on race/ethnicity) and were excluded from the adjusted model.
** Unadjusted model assessed an empty model, with only vaccination status (outcome), race/ethnicity (exposure), and barriers to vaccination (mediator).
***Adjusted model includes having at least one comorbid condition (p = 0.04) and doctor's recommendation (p < 0.01).

minorities were more likely to be unvaccinated against influenza. Furthermore, we discovered that this relationship was mediated by barriers to vaccination.

The proportion of adults receiving the influenza vaccination (40.4%) in LKRMC during the 2016-17 influenza season was slightly lower than the national 2016-17 adult influenza vaccination rate in the US (43.3%) [5]. Similar disparities in influenza vaccination existed between samples in LKRMC and national samples used by the Centers for Disease Control and Prevention (CDC) [5-7, 9, 18 39-41]. White adults (45.7%) and racial/ethnic minorities (36.3%) in LKRMC were vaccinated in roughly equal proportions to Whites (45.9%) and Blacks (37.4%)/Hispanics (36.9%) in the national sample [5].

Racial/ethnic minorities typically hold more negative beliefs regarding influenza vaccination, lack trust in the influenza vaccine (i.e., belief that the vaccine will cause illness), misunderstand risks of the influenza virus, believe that seeking the vaccine is inconvenient, and experience barriers such as cost, lack of insurance, and lack of access [12, 16, 18-20, 22, 27, 30, 31. 35, 42, 43]. This held true in this study. Racial/ethnic minorities in the sample were more likely to report higher rates of barriers to vaccination, including negative attitudes and beliefs and healthcare access barriers, than Whites. When the aggregated vaccination barrier score is considered in a mediated model, the direct relationship between race/ethnicity and vaccination status disappears

and is replaced by the indirect relationship mediated by barriers to vaccination. These results suggest complete mediation, where there is an observed indirect effect and no observed direct effect [44]. Complete mediation is the gold standard and reflects strong evidence that the relationship between race/ethnicity and vaccination status is mediated by barriers to vaccination.

The total effect is the sum of the indirect effect and the direct effect and measures the overall effect of the independent variable (race/ethnicity) on the dependent variable (vaccination status) [45]. Traditional mediation analysis, or the "causal steps approach," popularized by Baron and Kenny calls for a significant total effect to consider whether mediation analysis should be used [44]. However, more recent literature suggests that a significant total effect is not required for mediation to be present [45-52]. In fact, in the presence of complete mediation, one may not uncover a significant total effect and still have enough power to detect a significant indirect effect [51]. This anomaly occurs because the power to detect the total effect is dramatically less than the power to detect the indirect effect [51]. In the adjusted model of this study, the total effect does not reach significance, but given the preponderance of recent literature suggesting that a significant total effect is not required, this result does not nullify the mediation of the race/ethnicity-vaccination status relationship by barriers to vaccination.

The final, mediated model also controlled for provider recommendation and having at least one comorbid condition. These factors are consistent predictors of influenza vaccination across studies [17-21]. In fact, there is typically no stronger predictor of influenza vaccination than a provider recommendation [18-21]. Those with comorbid conditions for increased influenza-associated morbidity and mortality are more likely to be in care and are likely to be a focal point for provider vaccination efforts given their risk status. These factors likely contribute to the increased likelihood of vaccination for those with comorbid conditions. Provider recommendation and having at least one comorbid condition are also potentially associated with race/ethnicity. It has been suggested that providers may recommend the influenza vaccination with varying frequency based on race/ethnicity [13, 16, 34]. Additionally, one study has shown that Whites with comorbid conditions for increased influenza-associated morbidity and mortality were more likely than Blacks with the same conditions to receive an influenza vaccination [17]. As such, it follows that these factors would prove to confound the relationship between race/ethnicity and influenza vaccination status.

LIMITATIONS

The data used in this study are cross-sectional, making causal inference impossible. There are several studies that have shown that substantial bias can results from the use of cross-sectional data in mediation analysis [53-55]. However, many of these concerns arise as a result of interpreting cross-sectional results as temporal or causal [56]. The results presented in this study are atemporal, indicating that longitudinal observation is not necessary to quantify their effects. Additionally, we make no claims that the proposed mediation model represents a causal mechanism. Instead, identify that race/ethnicity is atemporally associated with influenza vaccination and that this association is mediated by barriers to vaccination.

Surveys were administered in hospital outpatient clinics, potentially introducing selection bias into the study. Those in outpatient clinics are more likely to have access to care than those in the general public. Increased access to care can lead to more points of contact between patient and provider and an increased likelihood of a provider recommendation. This may increase the likelihood of influenza vaccination and decrease the likelihood of negative attitudes and beliefs regarding the influenza vaccination and indicate a decreased degree of healthcare access barriers to influenza vaccination. The resulting bias would likely be towards the null as the rate of vaccination would be artificially increased and the vaccination barrier score would be artificially decreased. The outcome, influenza vaccination, is self-reported. Potential misclassification is introduced due to recall bias and social desirability bias. However, this misclassification is likely non-differential, which only serves to bias the associations towards the null.

Surveys were administered in a single medical center in rural Louisiana. As a result, the population surveyed will not be generalizable to the US population. However, there are likely similarities between this study and other hospitals and clinics in rural America. Influenza vaccination rates among rural racial/ethnic minorities are generally lower than those of rural non-minorities, urban racial/ethnic minorities, and urban non-minorities with regards to influenza vaccination, making this population of particular interest [10].

STRENGTHS

The relationship between race/ethnicity and influenza vaccination is complex and multifaceted. This study accounts for differing racial/ethnic experiences and attitudes regarding influenza vaccination through a mediated model. Additionally, this study was conducted in a rural population. Available literature suggests that rural populations may be less likely to receive influenza vaccination, particularly rural racial/ethnic minorities [10]. Finally, this study ensured internal validity by administering surveys orally and combining survey responses with patient medical records.

Conclusions

The results of this study indicate that the relationship between race/ethnicity and vaccination status is mediated by measured barriers to vaccination, both attitudinal and to healthcare access. This provides valuable information on how to increase vaccination rates among racial/ethnic minorities. Typical efforts made to increase vaccination in medical settings such as standing orders, EHR reminders, and other efforts to increase provider recommendation are proven to be effective, but there is a substantial opportunity to increase vaccine uptake among racial/ethnic minority populations by addressing how providers recommend the influenza vaccine. Providers should focus on minimizing fears that the vaccine will cause influenza and emphasize that the influenza vaccine is not only safe and effective at preventing severe influenza-associated illness, but must be administered every year to provide protection. Additional efforts should be made to improve the accessibility of the influenza vaccination, including addressing costs of vaccines and expanding the number and types of setting where vaccines are available.

There are several opportunities for future research. Now that several aggregated constructs have been established as mediating factors in the race/ethnicity-influenza vaccine uptake relationship in a limited population, these constructs should be tested in larger populations that are more representative of the general US adult population. Additional constructs should also be included in the measurement of barriers to vaccination, including perceived discrimination and patient trust in the provider.

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Conflicts of Interest

The authors report no conflicts of interest.

Authors' Contributions

Dr. Maloney designed and implemented this study, collected data, performed analyses, and authored the manuscript. Ms. Tietjer designed the REDCap database used in this study and assisted in data collection. Drs. Rung, Straif-Bourgeois, and Peters provided consultation on study design and analysis and edited this manuscript. Dr. Couk aided in implementation in LAK. He coordinated with hospital administration and helped secure necessary approvals. He also edited this manuscript.

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THE MEDIATING EFFECTS OF BARRIERS TO VACCINATION ON THE RELATIONSHIP BETWE-
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