Received: 16 July 2021 | Accepted: 28 September 2021
DOI: 10.1002/jmv.27368

RESEARCH ARTICLE

JOURNAL OF MEDICAL VIROLOGY WILEY

Assessing influenza vaccination success to inform COVID-19 vaccination campaign

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Abstract

Given recent downward trends in daily rates of COVID-19 vaccinations, it is important to reassess strategies to reach those most vulnerable. The success and efficacy of vaccination campaigns for other respiratory illnesses, such as influenza, may help inform messaging around COVID-19 vaccinations. This cross-sectional study examines the individual-level factors associated with, and the spatial distribution of, predictors of COVID-19 severity, and uptake of influenza and hepatitis B (as a negative control) vaccines across NYC. Data were obtained from the 2018 Community Health Survey (CHS), including self-reported influenza and hepatitis B vaccine uptake, diabetes, asthma, hypertension, body mass index (BMI), age, race/ethnicity, educational attainment, borough, and United Hospital Fund (UHF) neighborhood of residence. A CDC-defined COVID-19 severity risk score was created with variables available in the CHS, including diabetes, asthma, hypertension, BMI ≥ 30 kg/m^2, and age ≥65 years old. After adjustment, there was a significant positive association between COVID-19 severity risk score and influenza vaccine uptake (1: OR_{adj} = 1.49, 95% CI 1.28–1.73; 2: OR_{adj} = 1.99; 95% CI: 1.65–2.41; 3+: OR_{adj} = 2.89; 95% CI: 2.32–3.60, compared to 0). Hepatitis B vaccine uptake was significantly inversely associated with COVID-19 severity risk score (1: OR_{adj} = 0.67; 95% CI: 0.57–0.79; 2: OR_{adj} = 0.54; 95% CI: 0.44–0.66; 3+: OR_{adj} = 0.45; 95% CI: 0.36–0.56, compared to 0). The influenza vaccination campaign template is effective at reaching those most at risk for serious COVID-19 and, if implemented, may help reach the most vulnerable that have not yet been vaccinated against COVID-19.

KEYWORDS
influenza, immunization strategy, SARS-COV2

1 | INTRODUCTION

New York City (NYC) was an early and devastating epicenter of the coronavirus (COVID-19) pandemic in the United States with a cumulative reported case rate of 12,589.2 and a death rate of 404.5 per 100,000 residents as of September 16, 2021.[1] However, over a year into the pandemic, NYC has made significant progress in reducing virus spread, hospitalizations, and death through public health measures and vaccinations. As of September 15, 2021, 61.9% and 69.3%[2] of NYC residents were fully vaccinated or had received at least one dose, respectively, compared to 54.1% and 63.4% nationally.[3] While these numbers indicate considerable progress, vaccine distribution and uptake have been uneven across NYC.[4,5] This mirrors racial and socioeconomic disparities also seen in the distribution of COVID-19 cases and testing[6] where less affluent neighborhoods with large nonwhite populations have consistently fared worse.[7] Recent demand for COVID-19 vaccines has tapered, with available doses outpacing demand.[8] The drop-off in COVID-19 vaccination rates points to a need to improve the campaign and messaging around COVID-19 vaccinations, as the grim reality of COVID-19 hospitalizations and deaths may not be sufficient to motivate the hesitant pockets of the population. COVID-19 vaccine hesitancy and acceptance vary across racial and ethnic groups,[9] and reasons for having not yet received a vaccine include virus skepticism, a desire to get more information and see how things play out, a perceived lack of time or monetary resources, and distrust in the healthcare system.[10]

Understanding the uptake of the influenza vaccine, another contagious respiratory illness, could help provide insight into the features of vaccination campaigns that are successful in reaching those most vulnerable to severe illness, given that many of the risk factors for influenza severity overlap with the risk factors for COVID-19 severity, including age ≥65 years of age, chronic health conditions (asthma, heart disease, kidney disease, liver disease, and diabetes), high body mass index (BMI), immunosuppression, and pregnancy.[11–17] NYC Health + Hospitals has an ongoing "Fight the Flu!" campaign, offering information and free influenza vaccines at locations across the city.[18] In 2020, preceding the onset of the COVID-19 pandemic, the NYC Department of Health launched an influenza campaign that ran on public transport and social media with the main message, "This year's flu vaccination could be the most important one you ever get."[19] If influenza vaccination campaigns in previous years were successful in reaching the most vulnerable and at-risk demographics, similar strategies could be adopted for COVID-19 vaccines, and may provide a template for better reaching individuals who have yet to be vaccinated against COVID-19.

To understand if the influenza vaccine uptake in NYC was successful in reaching the most vulnerable, and how the results can be applied to COVID-19 specifically, we set the following objectives for this analysis: (1) identify the spatial distribution of COVID-19 severity risk scores and influenza vaccine uptake according to United Hospital Fund (UHF) neighborhood across NYC; (2) assess the independent associations of influenza vaccine uptake with COVID-19 severity risk score, race/ethnicity, education, and borough; and (3) as a negative control, assess the independent associations of the listed factors with hepatitis B vaccine uptake, a disease that has different transmission modality and risk factors. We hypothesize that COVID-19 severity risk will be associated with influenza vaccine uptake, but not with hepatitis B vaccine uptake.

2 | METHODS

2.1 | Data source

The Community Health Survey (CHS) is a cross-sectional telephone survey conducted annually by the NYC Department of Health and Mental Hygiene (DOHMH) on a stratified random sample of approximately 10,000 NYC residents ≥18 years old and living in non-group quarters. The survey includes data on demographics, neighborhood of residence, and self-reported measures of chronic diseases and behavioral health risk factors.[20]

This study used data from the 2018 CHS (n = 10,076). The primary outcomes of interest were self-reported influenza and hepatitis B vaccine uptake. Information on other variables of interest, including self-reported diabetes, asthma, high blood pressure, body mass index (BMI), age at interview, race/ethnicity, highest level of education attained, borough of residence, and United Hospital Fund (UHF) neighborhood of residence were extracted from the survey. A summary of the included variables can be found in Table S1.

2.2 | COVID-19 severity risk score

As previously published,[15,21] a risk score for severe COVID-19 was defined based on a count of individual risk factors identified by the Centers for Disease Control and Prevention (CDC)[11] as predictors of COVID-19 severity, and available in the CHS. These included diabetes, asthma, high blood pressure, BMI ≥ 30 kg/m^2, and age ≥65 years old. Risk index scores ranged from 0 to 5 and were collapsed into categories 0, 1, 2, and 3+, with 0 indicating least risk and 3+ indicating greatest risk of severe COVID-19.

2.3 | Statistical analyses

Participants were excluded from analyses if they were missing information about self-reported influenza vaccination or information for any variable used to define the COVID-19 severity risk score.

The distribution of self-reported influenza vaccine uptake, hepatitis B vaccine uptake, and COVID-19 risk index scores were mapped according to UHF using ArcGIS, v10.8.

Participants with and without a self-reported influenza vaccine in the previous year were compared on all demographic and risk factor variables using χ^2 tests. Multivariable logistic regression analysis was performed to assess the independent association of the COVID-19 severity risk score with self-reported influenza vaccine uptake, adjusting for race/ethnicity, education, and borough of residence. Among participants with definitive information about whether they had ever received the hepatitis B vaccine, a similar model was run to assess the association with hepatitis B vaccine uptake, as a negative control. Correlations between individual risk factors and influenza vaccine uptake were assessed to identify factors most associated with vaccine uptake. Multivariable models were run on the subset of participants with complete data. All analyses were performed using SAS software, version 9.4 (SAS Institute). All analyses used the suite of "survey" procedures in SAS to account for the complex sampling design of the CHS. All presented results represent weighted values.

3 | RESULTS

There were 9,740 CHS respondents in 2018 with complete information on influenza vaccination and variables contained in the COVID-19 severity risk score; 47% of whom reported receiving the

TABLE 1 Description of the population according to influenza vaccine uptake

Variable	Influenza vaccine *N* (%) Yes: *N* = 4908 (46.8)	No: *N* = 4832 (53.2)	*p*
Diabetes			<0.0001
Yes	939 (14.9)	560 (7.4)	
No	3969 (85.1)	4272 (92.6)	
Asthma			<0.0001
Yes	304 (6.0)	178 (3.1)	
No	4604 (94.0)	4654 (96.9)	
High blood pressure			<0.0001
Yes	2056 (31.5)	1382 (21.2)	
No	2852 (68.5)	3450 (78.8)	
BMI (kg/m^2)			0.0747
<30	3502 (73.0)	3544 (75.4)	
≥30	1406 (27.0)	1288 (24.6)	
Age (years)			<0.0001
<65	3122 (79.3)	3810 (89.4)	
≥65	1786 (20.7)	1022 (10.6)	
COVID- 19 severity risk score (0 = low risk; 5 = high risk)			<0.0001
0	1567 (43.5)	2273 (57.0)	
1	1339 (28.1)	1320 (25.7)	
2	1108 (16.7)	734 (11.6)	
≥3	894 (11.7)	505 (5.7)	
Race			0.0427
White, non-Hispanic	1808 (37.2)	1572 (33.8)	
Black, non-Hispanic	1049 (20.4)	1195 (23.9)	
Hispanic	1389 (26.5)	1398 (27.1)	
Asian/PI, non-Hispanic	549 (13.7)	522 (12.9)	
Other, non-Hispanic	113 (2.2)	145 (2.2)	
Educational Attainment			0.0116
Less than high school	787 (18.8)	681 (16.7)	
High school graduate	1032 (22.8)	1063 (25.5)	
Some college/ technical school	969 (21.2)	1101 (23.8)	
College graduate	2092 (36.5)	1963 (33.5)	
Missing/Unknown	28 (0.7)	24 (0.5)	
Borough			0.0003
Bronx	944 (17.5)	865 (15.2)	
Brooklyn	1473 (27.3)	1675 (32.2)	
Manhattan	1019 (22.7)	815 (18.4)	
Queens	1183 (27.0)	1235 (28.5)	
Staten Island	289 (5.5)	242 (5.6)	
Hepatitis B vaccine			<0.0001
Yes	2442 (54.8)	1998 (44.5)	
No	1864 (32.9)	2290 (43.8)	
Missing/Unknown	602 (12.2)	544 (11.7)	

Note: Self-reported influenza vaccination uptake, hepatitis B vaccination uptake, diabetes, asthma, BMI ≥ 30 (mg/k^2), age ≥65 years, racial/ethnic demographics, education, and borough were obtained from the 2018 DOHMH Community Health Survey (CHS)[2]; categories were recoded as Yes versus No/Don't know/Refused. COVID-19 Severity Risk Score, according to the criteria for COVID-19 severity risk established by the CDC, included count data of diabetes, asthma, high blood pressure, BMI ≥ 30 kg/m^2, and residents ≥65 years old, which was also sourced from the 2018 DOHMH Community Health Survey (CHS).[2]

influenza vaccine within the last year (Table 1). Those with an influenza vaccine were significantly more likely to report having diabetes (14.9% vs. 7.4%; p < 0.0001), asthma (6.0% vs. 3.1%; p < 0.0001), high blood pressure (31.5% vs. 21.2%; p < 0.0001), and to be ≥65 years old (20.7% vs.10.6%; p < 0.0001) than those who had not received influenza vaccine. Those who received the influenza vaccine had significantly (p < 0.0001) higher COVID-19 severity risk scores (11.7% vs. 5.7% for scores ≥3). There was also a statistically significant difference by race (p = 0.0427), with those who received an influenza vaccine more likely to be non-Hispanic white (NHW) (37.2% vs. 33.8%) and less likely to be non-Hispanic Black (NHB) (20.4% vs. 23.9%). There was a significant association between influenza vaccination status and educational attainment (p = 0.0116), with greater numbers of college graduates among those who were vaccinated than those who were not (36.5% vs. 33.5%). Those who received an influenza vaccine were significantly (p = 0.0003) more likely to reside in Manhattan (22.7% vs. 18.4%) and the Bronx (17.5% vs. 15.2%), and less likely to reside in Brooklyn (27.3% vs. 32.2%) and Queens (27.0% vs. 28.5%), compared to those who did not receive an influenza vaccine. Those who received an influenza vaccine were also significantly more likely to have received a hepatitis B vaccine (54.8% vs. 44.5%; p < 0.0001). The distribution of the COVID-19 risk index scores was mapped according to the 34 UHF areas in NYC, as were influenza vaccine uptake and hepatitis B vaccine uptake (Figure 1). Across NYC, areas with higher COVID-19 risk scores generally had higher influenza vaccine uptake, with the exception of Manhattan. Overall, there was an inverse relationship between influenza vaccination uptake and hepatitis B uptake in the Bronx, Staten Island and across some areas in Queens. Mean COVID-19 severity risk scores by UHF ranged from 0.52 to 1.10, with higher risk individuals concentrated in the Bronx and Staten Island. The percentage of residents who received an influenza vaccine ranged from 28.7% to 60.7%, with higher influenza vaccine uptake concentrated in areas of Manhattan and the Bronx. The percentage of people who received a Hepatitis B vaccine ranged from 39.7% to 70.6%, with higher hepatitis B vaccine uptake concentrated in Manhattan.

After adjusting for all covariates ($n = 9,688$), people were significantly more likely to report having had an influenza vaccine with increasing COVID-19 severity risk score (1: $OR_{adj} = 1.49$, 95% CI 1.28–1.73; 2: $OR_{adj} = 1.99$, 95% CI 1.65–2.41; 3+: $OR_{adj} = 2.89$, 95% CI 2.32–3.60, compared to 0). When compared to NHW residents, NHB residents ($OR_{adj} = 0.76$, 95% CI 0.64–0.92) were significantly less likely to report an influenza vaccine, whereas there was no statistically significant difference in influenza vaccine uptake for

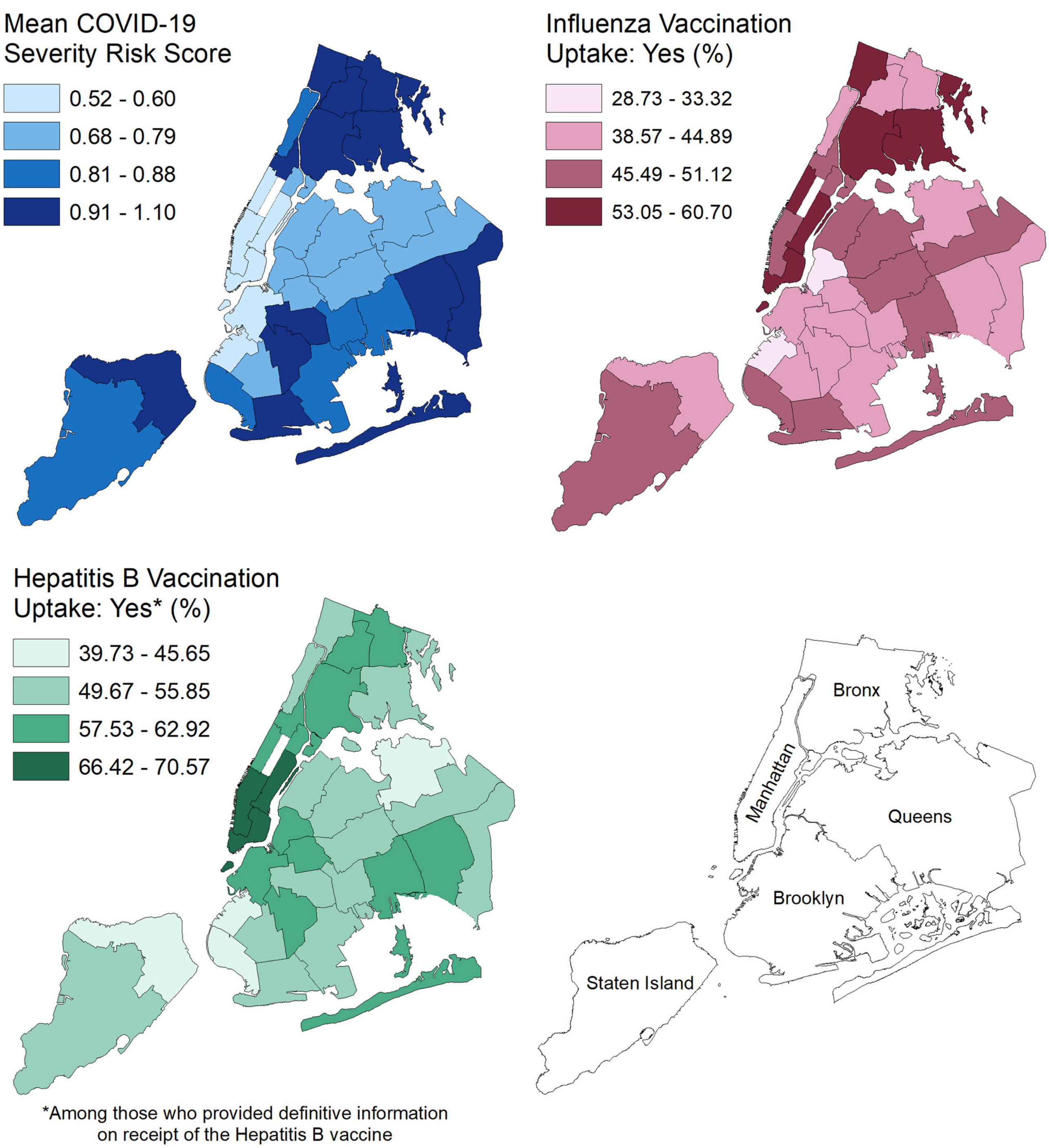

FIGURE 1 Spatial distribution of mean COVID-19 severity risk score, influenza vaccine uptake, and hepatitis B vaccine uptake, by United Hospital Fund area across New York City. A key for the geography of New York City boroughs is included in the figure

residents who are Asian/Pacific Islander, Hispanic, or of any other race. There was no statistically significant difference in influenza vaccine uptake according to highest level of education. Finally, across NYC boroughs, when compared to Manhattan, residents of Brooklyn and Queens were significantly less likely to report having influenza vaccine ($OR_{adj} = 0.70$, 95% CI 0.59–0.84 and $OR_{adj} = 0.76$, 95% CI 0.62-0.92, respectively) (Table 2). When we studied the individual components of the COVID-19 risk score, we observed a statistically significant positive association between influenza vaccine uptake and self-reported diabetes ($\rho = 0.12$, $p < 0.0001$), high blood pressure ($\rho = 0.12$, $p < 0.0001$), and age ≥65 years old ($\rho = 0.14$, $p < 0.0001$). After adjusting for all covariates, diabetes ($OR_{adj} = 1.68$; 95% CI: 1.37–2.07), high blood pressure ($OR_{adj} = 1.32$; 95% CI: 1.13–1.54), age ≥65 years old ($OR_{adj} = 1.80$; 95% CI: 1.53–2.13), and asthma ($OR_{adj} = 1.88$; 95% CI: 1.37–2.58) were found to be significant drivers of association between the composite COVID-19 severity risk score and influenza vaccine uptake.

3.1 | Hepatitis B vaccine (negative control)

After adjusting for all covariates ($n = 8,591$), people were significantly less likely to report having had a hepatitis B vaccine with increasing COVID-19 severity risk score (1: $OR_{adj} = 0.67$; 95% CI: 0.57–0.79; 2:

TABLE 2 Relative Odds of influenza and hepatitis B vaccination uptake according to COVID-19 risk score, after adjusting for race/ethnicity, educational attainment, and borough

	Influenza vaccination			Hepatitis B vaccination		
Variable	Adjusted odds ratio (OR_{adj})	95% Confidence limits		Adjusted odds ratio (OR_{adj})	95% Confidence limits	
COVID-19 severity risk score (0 = low risk; 5 = high risk)						
0	1.0	ref.	–	1.0	ref.	–
1	1.49	1.28	1.73	0.67	0.57	0.79
2	1.99	1.65	2.41	0.54	0.44	0.66
≥3	2.89	2.32	3.60	0.45	0.36	0.56
Race/ethnicity						
White, non-Hispanic	1.0	ref.	–	1.0	ref.	–
Asian/Pacific Islander, non-Hispanic	1.12	0.90	1.39	1.16	0.91	1.46
Black, non-Hispanic	0.76	0.64	0.92	1.29	1.06	1.56
Hispanic	0.85	0.71	1.01	1.29	1.06	1.57
Other, non-Hispanic	0.89	0.60	1.32	1.16	0.71	1.88
Educational attainment						
Less than high school	1.0	ref.	–	1.0	ref.	–
High school graduate	0.86	0.70	1.07	1.30	1.04	1.63
Some college/ technical school	0.87	0.71	1.08	1.95	1.55	2.45
College graduate	1.05	0.86	1.29	2.07	1.66	2.58
Borough						
Manhattan	1.0	ref.	–	1.0	ref.	–
Bronx	0.98	0.80	1.21	0.89	0.71	1.11
Brooklyn	0.70	0.59	0.84	0.74	0.61	0.90
Queens	0.76	0.62	0.92	0.72	0.58	0.88
Staten Island	0.76	0.54	1.05	0.60	0.42	0.87

Note: COVID-19 severity risk score, according to the criteria for COVID-19 severity risk established by the CDC, included count data of diabetes, asthma, high blood pressure, BMI ≥ 30 kg/m^2, and residents ≥65 years old, which were obtained from the 2018 DOHMH Community Health Survey (CHS),[2] as well as self-reported influenza vaccination uptake, racial/ethnic demographics, education, and borough.

OR_{adj} = 0.54; 95% CI: 0.44–0.66; 3+: OR_{adj} = 0.45; 95% CI: 0.36–0.56, compared to 0). NHB residents (OR_{adj} = 1.29; 95% CI: 1.06–1.56) and Hispanic residents (OR_{adj} = 1.29; 95% CI: 1.06–1.57) were significantly more likely to report having a hepatitis B vaccine, compared to NHW residents. There was no statistically significant difference in hepatitis B vaccine uptake for Asian/Pacific Islander residents or those of any other race. Hepatitis B vaccine uptake increased significantly with increasing levels education (high school graduate: OR_{adj} = 1.30; 95% CI: 1.04–1.63; some college/technical school: OR_{adj} = 1.95; 95% CI: 1.55–2.45; college graduate: OR_{adj} = 2.07; 95% CI: 1.66–2.58, when compared to less than high school education). Finally, across NYC boroughs, when compared to Manhattan, residents of Brooklyn, Queens, and Staten Island were significantly less likely to report having a hepatitis B vaccine (OR_{adj} = 0.74; 95% CI: 0.61–0.90; OR_{adj} = 0.72; 95% CI: 0.58–0.88; OR_{adj} = 0.60; 95% CI: 0.42–0.87, respectively) (Table 2).

4 | DISCUSSION

To the best of our knowledge, this is the first analysis to incorporate CDC-defined risk factors for COVID-19 severity, racial and ethnic composition, education, and borough to predict influenza vaccine uptake across NYC at the individual level. Here we identify that influenza vaccine uptake was highest among residents with higher COVID-19 severity risk scores, NHW residents, and residents of Manhattan borough. In comparison, residents that had higher COVID-19 severity risk scores had decreased hepatitis B vaccine uptake, whereas hepatitis B vaccine uptake was highest among NHB residents, Hispanic residents, residents with higher levels of education, and residents of Manhattan. These findings support our hypothesis that COVID-19 severity risk would be associated with influenza vaccine uptake, due to the shared risk factors for severity of both, but not associated with hepatitis B vaccine uptake.

These findings suggest that the campaign for influenza vaccination uptake has been successful, as influenza vaccine uptake was highest among residents most vulnerable to severe complications from influenza. Common influenza vaccination campaign strategies that have been shown to be successful include convenient, easy-access vaccinations,[22,23] sharing awareness via social media,[23] free or low-cost influenza vaccines, educational outreach into vulnerable areas,[24] simple, evidence-based messaging,[25] and consistent communication from healthcare providers.[22,23] While the influenza vaccine only reduces the risk of illness among 40%–60% of the population,[26] the influenza vaccine is still very effective in terms of uptake, particularly among those most at risk for severity, including those 65 years or older. Further, during the 2019–2020 influenza season, 69.8% of people 65 years or older nationally got the influenza vaccine.[27] This number was nearly 80% in NYC during the most recent influenza seasons through 2019. In addition, due to the COVID-19 pandemic, a record 175 million doses were provided during this last influenza season, and vaccine manufacturers have projected a jump from 175 million to 194–198 million for the upcoming 2021–2022 influenza season.[28] The success of the influenza vaccine is clear, even in light of the known limited efficacy. Since all of the vaccines for COVID-19 available in the United States are considerably more effective at preventing symptomatic disease and infection than influenza vaccine,[26,29–34] adopting the influenza vaccination campaign template for COVID-19 vaccinations to reach individuals most at risk for COVID-19 severity could obtain maximum benefit at the community level, greatly reducing COVID-19 infection and mortality. However, after adjusting for the COVID-19 risk score, NHB residents and residents outside of Manhattan are still less likely to get an influenza vaccine. This suggests that even though the influenza vaccination campaign is successful, there are still persisting racial and geographic disparities, consistent with other studies that have reported racial and geographic disparities in influenza vaccine uptake.[35,36] Although the influenza vaccination campaign may help increase vaccine uptake among vulnerable people, additional messaging should be tailored and focused specifically on nonwhite neighborhoods to further maximize the full benefit and address reported COVID-19 vaccine hesitancy among NHB residents[9] and other disadvantaged communities.[24]

Considering vaccine uptake overall, it could be argued that some people are simply more vaccine ready and health conscious, and more likely to follow health recommendations. To examine this, we used hepatitis B vaccine uptake as negative control, as hepatitis B is an infection with a completely different method of transmission, risk factors, and vaccine schedule, compared to influenza.[37,38] In the present analysis, we found that COVID-19 severity risk had an inverse relationship with hepatitis B vaccine uptake, which suggests that vaccine uptake is not all-inclusive of every vaccine but dependent on the specific one in question.

4.1 | Limitations

Due to the survey sampling methodology of the data used in this analysis, data for adults in households without any telephone service and adults living in group settings (e.g., college dormitories, nursing facilities) could not be obtained.[39] Additionally, the CHS does not include all CDC-defined risk factors for COVID-19 severity that would be important in this analysis, including COPD, cancer, chronic kidney disease, heart disease, pregnancy, previous heart attack, and liver disease. We also do not have information on where people obtained their influenza vaccinations, which would provide better insight into which specific strategies would drive the influenza vaccine campaign most. Finally, the survey used in this analysis relies on self-reported measures of chronic health diseases and behavioral risk factors, not clinical diagnostic and workup measures.

4.2 | Strengths

To the best of our knowledge, this is the only study using individual-level data on risk factors for COVID-19 severity and influenza vaccine uptake at the UHF level in NYC.

5 | CONCLUSION

Examining the factors associated with influenza vaccine uptake in NYC to understand the success of the influenza vaccination campaign can inform COVID-19 vaccine strategy to reach those who have not yet been vaccinated against COVID-19 but are most at risk for COVID-19 severity. This analysis confirms that the influenza vaccination campaign template is effective at reaching those most at risk for serious infection and proposes that it is a practical and successful template to encourage COVID-19 vaccine uptake of the most vulnerable. Future analyses should focus on examining racial and socioeconomic disparities in COVID-19 vaccine uptake and explore any barriers to uptake. To better reach those not yet vaccinated and those most vulnerable to severity from COVID-19 infection, widespread vaccination strategy should start with reforming the campaign around COVID-19 vaccines.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

AUTHOR CONTRIBUTIONS

Ashley Moreland had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design*, *drafting of the manuscript*, *critical revision of the manuscript for important intellectual content*, and *statistical analysis*: Emanuela Taioli, Ashley Moreland, and Naomi Alpert. *Acquisition, analysis, and interpretation of data*: Ashley Moreland, Naomi Alpert, Emanuela Taioli, and Christina Gillezeau. *Administrative, technical, or material support*: Christina Gillezeau, Naomi Alpert, and Emanuela Taioli. *Study supervision*: Emanuela Taioli.

DATA AVAILABILITY STATEMENT

Individual-level count data used for this analysis was obtained by the New York City Department of Health and Mental Hygiene's 2018 Community Health Survey with a signed data access agreement. The data dictionary for this data is publicly available at the following website: https://www1.nyc.gov/assets/doh/downloads/pdf/episrv/chs2018-codebook.pdf.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Moreland A, Gillezeau C, Alpert N, Taioli E. Assessing influenza vaccination success to inform COVID-19 vaccination campaign. *J Med Virol*. 2022;94:918-925. doi:10.1002/jmv.27368