Associations Between COVID-19 Vaccine Hesitancy and Socio-Spatial Factors in NYC Transit Workers 50 Years and Older

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Abstract
This analysis investigates how age, race/ethnicity, and geographic location contributed to vaccine hesitancy in a sample of 645 New York City (NYC) Transport Workers Union (TWU), Local 100 members surveyed in August 2020. Union members ages 50+ were 46% less likely to be vaccine hesitant than their younger counterparts (OR 0.64; 95% CI 0.42, 0.97). Non-Whites (OR 3.95; 95% 2.44, 6.39) and those who did not report their race (OR 3.10; 95% CI 1.87, 5.12) were significantly more likely to be vaccine hesitant than Whites. Those who were not concerned about contracting COVID-19 in the community had 1.83 greater odds (95% CI 1.12, 2.98) of being vaccine hesitant than those who were concerned. Older

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respondents tended to reside in Queens while vaccine hesitant and non-White respondents were clustered in Brooklyn. General trends observed in COVID-19 vaccine hesitancy persist in a population of high risk, non-healthcare essential workers.

Keywords
ADAR, COVID-19, vaccine hesitancy, essential workforce, public transit, older adults

A large and growing body of literature reveals that certain subpopulations have been disproportionately affected by the COVID-19 pandemic. These include racial/ethnic minority groups (Mude et al., 2021); those of lower socioeconomic status (Adhikari et al., 2020); essential workers or those unable to work remotely (Rogers et al., 2020); and those who are un- or underinsured (Khatana & Groeneveld, 2020). Although previous research has examined the impacts of COVID-19 on essential healthcare workers, there remains a gap in the literature regarding the experiences and impacts among non-healthcare essential workers. Public transportation workers’ experiences and struggles during the pandemic have lacked scholarly attention despite high levels of fear surrounding COVID-19 stemming from exposures and risks in their work and community environments (Dave, 2020; Gershon et al., 2021; Rice et al., 2021; Tomasi et al., 2021).

With the advent of COVID-19 vaccines, research has found that certain groups in the United States—many of whom have borne the burden of COVID-19 disparities throughout the pandemic—are more likely to be vaccine hesitant. These include Black and Hispanic/Latinx Americans (McFadden et al., 2022); younger Americans (McElfish et al., 2021); those who had already had COVID-19 (Do & Frank, 2022); those who do not know people affected by COVID-19 (Khubchandani et al., 2021); and those with low perceived personal risk of COVID-19 infection (Gerretsen et al., 2021). Major reasons cited for vaccine hesitancy include concerns about the vaccine itself, including vaccine safety, efficacy, side effects, and rapid development (Willis et al., 2021). Those who are vaccine hesitant have also expressed a lack of trust in pharmaceutical companies, the government, or other institutions (King et al., 2021). This often stems from past ethical abuses, existing systemic racism, and disparities in the modern healthcare system (Savoia et al., 2021). Vaccine hesitancy has also been shown to relate to low levels of fear, as well as misinformation and a lack of connection and effective communication between scientists and the general public (McElfish et al., 2021). Although differences in COVID-19 vaccine hesitancy based on race/ethnicity are well-documented, not as much scholarly attention has been paid to differences in vaccine hesitancy based on age. Older adults have generally been found to be less vaccine hesitant than their younger counterparts (Gerretsen et al., 2021; McElfish
et al., 2021; Sallam, 2021), though these age differences have not been studied in-depth.

This study examines COVID-19 vaccine hesitancy among Transport Workers Union (TWU), Local 100 members who are employees of the New York City (NYC) Metropolitan Transit Authority (MTA), paying particular attention to older adults. This workforce provides an important case study to better understand the health beliefs and behaviors of a non-healthcare essential workforce during the COVID-19 pandemic. NYC’s experience with COVID-19 has oftentimes served as a bellwether for other parts of the country.

Several studies have examined the social determinants of COVID-19 disparities within NYC. Sy et al. (2021) coined “social distancing inequity,” whereby those of lower socioeconomic status are more likely to be essential workers who are unable to work from the safety of their homes. Parts of the Bronx and Queens with lower median household income, a greater proportion of non-White residents, and a greater share of essential workers have had greater mobility based on subway ridership than other parts of the city. However, the proportion of essential workers was the only significant predictor of mobility (Sy et al., 2021). Mobility, in turn, was associated with greater COVID-19 incidence in these areas (Sy et al., 2021). Bronx residents largely identify as Black or Hispanic/Latinx, and were living in overcrowded housing, participating in the essential workforce, and sustaining subway use during COVID-19 (“COVID-19 Cases in New York City, a Neighborhood-Level Analysis,” 2020). Researchers have also pinpointed “vaccination access deserts” in low-income communities of color across Brooklyn. Zip code-level disparities in COVID-19 testing and the proportion of positive tests throughout NYC have been shown to be based on average income levels, race/ethnicity, educational attainment, and health coverage (Cordes & Castro, 2020; Williams et al., 2021).

Given the constantly evolving climate of COVID-19 vaccine hesitancy, this study seeks to investigate potential differences in vaccine hesitancy based on age, race/ethnicity, chronic disease health status, and geographical location among a sample of NYC essential public transportation workers.

**Methods**

**Sample and Data Collection**

In partnership with the Transport Workers Union, Local 100, a stratified convenience sample (based on job type) of 645 respondents out of 35,000 union members employed by the NYC MTA completed an anonymous, cross-sectional online survey over a three-week-period in August 2020. The survey addressed four main themes: demographic and occupational characteristics and protections at work; history of COVID-19 infection; vaccine intentions and reasons for vaccine hesitancy; fear for safety at work; and mental health symptoms. Participation was entirely voluntary, and respondents were not compensated for their time. All procedures were approved
by the New York University Institutional Review Board and full study procedure details can be found elsewhere (Gershon et al., 2021).

Measures

The outcome of interest was vaccine hesitancy based on the question, “When it becomes available, do you intend to take the COVID-19 vaccine?” A dichotomous variable was created, where a response of “Yes” served as the reference category, and responses of “No” or “Not sure” were considered vaccine hesitant. Age was investigated as the primary exposure of interest, dichotomized as those younger than 50 years old (reference) and those 50 years or older.

The self-reported race was based on three categories: White (reference), non-White (including Black/African American, Asian/Native American/Native Hawaiian/Pacific Islander, and multiracial), and those respondents who opted not to report their race. Ethnicity was dichotomized as non-Hispanic/Latinx (reference) versus Hispanic/Latinx. Sex was categorized as male (reference group) versus female. The response categories for pre-existing health conditions included none (reference) versus at least one.

Self-reported history of COVID-19 infection was determined by a positive response to any one of the following questions: a positive diagnosis from a healthcare professional, a positive nasal swab (PCR) test, history of hospitalization for COVID-19 symptoms, or a positive COVID-19 antibody test. COVID-19 infection history was dichotomized as no (reference) versus yes. Other questions surrounding the history of COVID-19 exposure included, “Do you know anyone who has been infected with COVID-19?” and “Do you know anyone who has died from COVID-19?” both of which were treated as dichotomous variables with a response of “No” as the reference. Risk perception was assessed through the questions, “Are you concerned about getting COVID-19 at work?” and “Are you concerned about getting COVID-19 in the community?” These were also treated as dichotomous variables, with “Yes” as the reference group. Zip code was self-reported by survey respondents. Other covariates included job type, which was dichotomized as non-public facing (reference) versus public facing.

Statistical and Spatial Analyses

To determine the predictors of vaccine hesitancy, univariate and bivariate analyses were first conducted, followed by multivariable logistic regression. All statistical analyses were conducted in Stata 17 (StataCorp, 2021). For data visualization, data analysis for matching respondents’ self-reported zip codes to other variables was completed in Python version 3.7.6 with pandas, NumPy, and Matplotlib libraries (Van Rossum & Drake, 2009). The Folium 0.12.1 library (https://python-visualization.github.io/folium/) was used for mapping the geospatial data, and the zip code data for NYC was obtained via a public GitHub repository (https://github.com/fedhere/PUI2015_EC/blob/master/mam1612_EC/nyc-zip-code-tabulation-areas-polygons.geojson).
Table 1. Distribution of Selected Population Characteristics by Intent to get Vaccinated, Transport Workers Union, Local 100, New York City, August 2020.

|                          | N     | Vaccination intent—no/not sure | p-value |
|--------------------------|-------|--------------------------------|---------|
| **Total**                | 604   | 71%                            |         |
| Age group                |       |                                |         |
| Younger than 50          | 243   | 77%                            |         |
| 50 years or older        | 361   | 66%                            | .004    |
| Job type<sup>a</sup>     |       |                                |         |
| Non-public facing        | 230   | 67%                            | .153    |
| Public facing            | 372   | 67%                            |         |
| **Sex<sup>a</sup>**      |       |                                |         |
| Male                     | 477   | 67%                            | <.001   |
| Female                   | 111   | 87%                            |         |
| Race                     |       |                                |         |
| White                    | 207   | 52%                            |         |
| Non-White                | 229   | 82%                            |         |
| Not reported             | 168   | 79%                            | <.001   |
| Ethnicity<sup>a</sup>    |       |                                |         |
| Non-Hispanic/Latinx      | 391   | 70%                            |         |
| Hispanic/Latinx          | 150   | 69%                            | .912    |
| History of COVID infection|      |                                |         |
| Yes                      | 150   | 72%                            |         |
| No                       | 454   | 70%                            | .723    |
| Known someone with COVID<sup>a</sup> |     |                                |         |
| Yes                      | 548   | 71%                            | .594    |
| No                       | 54    | 74%                            |         |
| Known someone who died<sup>a</sup> |    |                                |         |
| Yes                      | 457   | 72%                            | .151    |
| No                       | 144   | 66%                            |         |
| COVID concern at work<sup>a</sup> |    |                                |         |
| Yes                      | 523   | 71%                            | .377    |
| No                       | 52    | 77%                            |         |
| COVID concern in community<sup>a</sup> |   |                                |         |
| Yes                      | 411   | 68%                            | .021    |
| No                       | 138   | 78%                            |         |
| Serious health condition<sup>a</sup> |  |                                |         |
| None                     | 226   | 68%                            |         |

(Continued)
Subject data was matched to their respective self-reported zip code, and frequency of responses to the desired variables were color mapped and plotted on a NYC map of the five boroughs divided into regions based on each zip code.

**Results**

Table 1 shows the descriptive statistics for the analytic sample of 604 respondents who reported their intent to get vaccinated. Roughly 71% of respondents (428 individuals)
| Table 2. Logistic Regression Adjusting for Covariables Predicting Vaccine Hesitancy among Transport Workers Union, Local 100 Members, New York City, August 2020, $N = 533$. |
|------------------------------------------|
|                          | Crude odds ratios (95% CI) | Adjusted* odds ratio (95% CI) |
|------------------------------------------|
| **Age group**                          |                          |                                |
| Under 50                                | 1.00                     | 1.00                           |
| 50 and older                            | 0.58** (0.40, 0.84)      | 0.64* (0.42, 0.97)             |
| **Sex**                                 |                          |                                |
| Male                                    | 1.00                     | 1.00                           |
| Female                                  | 2.91** (1.66, 5.12)      | 1.80 (0.95, 3.42)              |
| **Race**                                |                          |                                |
| White                                   | 1.00                     | 1.00                           |
| Non-White                               | 4.20** (2.72, 6.49)      | 3.95*** (2.44, 6.39)           |
| **Refused to respond**                  |                          |                                |
| 3.36** (2.13, 5.32)                     | 3.10*** (1.87, 5.12)     |                                |
| **COVID concern in community**          |                          |                                |
| Yes                                     | 1.00                     | 1.00                           |
| No                                      | 1.70* (1.08, 2.68)       | 1.83* (1.12, 2.98)             |
| **Job type**                            |                          |                                |
| Non-public facing                       | 1.00                     |                                |
| Public facing                           | 1.30 (0.91, 1.86)        |                                |
| **Serious health condition**            |                          |                                |
| None                                    | 1.00                     |                                |
| At least one                            | 1.43 (0.91, 2.24)        |                                |
| **History of COVID infection**          |                          |                                |
| Yes                                     | 1.00                     |                                |
| No                                      | 0.93 (0.62, 1.40)        |                                |
| **Known someone with COVID**            |                          |                                |
| Yes                                     | 1.00                     |                                |
| No                                      | 1.19 (0.63, 2.24)        |                                |

(Continued)
expressed vaccine hesitancy and nearly 60% were 50 years or older (with a mean age of 50.7). The majority (61.8%) were in public-facing jobs and over 81% of the sample identified as male. The sample was relatively evenly distributed in terms of race, with 34.3% identifying as White, 37.9% identifying as non-White, and 27.8% refusing to report their race. Nearly 28% identified as Hispanic/Latinx. In terms of COVID-19 history and exposure, 24.8% had a personal history of infection, 91.0% knew someone who had been infected, and 76.0% knew someone who had died. The vast majority of respondents were concerned about contracting COVID-19 at work (91.0%) and in the community (76.0%). Most respondents resided in Brooklyn (39.9%), followed by Queens (24.3%), the Bronx (20.4%), Staten Island (9.3%), and Manhattan (6.1%). 42.3% of respondents had at least one chronic health condition. Bivariate analyses showed that those who identified as female, identified as non-White, or refused to report their race were significantly more likely to be vaccine hesitant. Respondents aged 50 and older and those who were concerned about contracting COVID-19 in the community were significantly less likely to be vaccine hesitant. Those who had known someone who had died from COVID-19 were concerned about contracting COVID-19 at work and had at least one chronic health condition tended exhibited less vaccine hesitancy, though these differences were not statistically significant.

Table 2 shows the results of univariate and multivariate logistic regressions predicting vaccine hesitancy. The adjusted model controlled for age group, race, sex, and concern about contracting COVID-19 in the community. Compared to those younger than 50, those ages 50 or older had 46% reduced odds of being vaccine hesitant (95% CI 0.42, 0.97). Those who identified as non-White (OR 3.95; 95% CI 2.44, 6.39) or refused to report their race (OR 3.10; 95% CI 1.87, 5.12) had significantly greater odds of being vaccine hesitant. In addition, those not concerned about contracting COVID-19 in the community had significantly greater odds of being vaccine hesitant than those who did express concern (OR 1.83; 95% CI 1.12, 2.98).

Table 2. Continued

| Known someone who died | Crude odds ratios | (95% CI) | Adjusted* odds ratio | (95% CI) |
|-------------------------|------------------|----------|----------------------|----------|
| Yes                     | 1.00             |          |                      |          |
| No                      | 0.75             | (0.50,   | 1.11)                |          |
| COVID concern at work   |                  |          |                      |          |
| Yes                     | 1.00             |          |                      |          |
| No                      | 1.35             | (0.69,   | 2.65)                |          |

Cl = confidence interval.
*After adjustment for age group, sex, race, and COVID concern in the community.
*p < .05, **p < .01, ***p < .001.
Figures 1 to 4 show maps of NYC with zip code-based spatial distributions of respondents by age, degree of vaccine hesitancy, binary race (White vs. non-White), and concern about contracting COVID-19 in the community, respectively. Based on the maps, older workers tended to reside in Queens, while younger workers were spread across zip codes throughout the Bronx, Brooklyn, and Queens. The largest cluster of zip codes where individuals responded that they would not take the vaccine should it become available were in an area of Brooklyn where predominantly...
Non-White workers also resided. There was general concern surrounding COVID-19 infection from within individuals’ communities throughout all boroughs.

**Discussion**

We were able to confirm several of our hypotheses surrounding COVID-19 vaccine hesitancy among NYC public transportation workers prior to vaccine availability. This was based on statistical and spatial analyses of data collected in partnership.
with the Transport Workers Union, Local 100 in August 2020. Those 50 years or older were less likely to be vaccine hesitant and non-White individuals and those who did not report their race were more likely to be vaccine hesitant. However, only individuals’ perception of community risk was significantly associated with vaccine hesitancy, whereas risk perception at work, personal history of COVID-19 infection, and knowing others infected or who had died from COVID-19 were not associated with vaccine hesitancy. Vaccine hesitancy, along with other associated variables, tended to show spatial distributions across NYC zip codes. These results are consistent with the general population trends surrounding COVID-19 vaccine hesitancy in terms of age and race, but not necessarily in terms of the personal history of infection or exposure to COVID-19. These findings may be reflective of the unique characteristics of this non-healthcare essential workforce, warranting further in-depth investigation.

Our findings support the suggestion that more efforts are necessary to address vaccine equity by removing barriers to access related to transportation, language, distrust, misinformation, insurance, and scheduling. One strategy to address “vaccination access deserts” in minority and low-income urban areas can include the establishment
of “vaccine equity task forces” (Strully et al., 2021). Effective public health messaging that considers context and history should occur alongside better communication and transparency between scientists and the public. This will improve trust within the community and community involvement in the vaccination process, especially by involving local trusted physicians and other healthcare providers (Bunch, 2021; Malik et al., 2020; Rosenbaum, 2021; Savoia et al., 2021; Strully et al., 2021).

This study has several limitations. At the time of the survey in August 2020, there was no federal approval for any COVID-19 vaccine, potentially making it harder for individuals to understand the possibility of a safe, viable vaccine. The cross-sectional study also precluded any ability to make causal inferences or observe changes in vaccine attitudes over time. Additionally, we acknowledge that a convenience sample of self-selected union members may not be representative of the entire MTA workforce. However, given the continued trends of vaccine hesitancy among non-healthcare essential workers, many of whom are non-White and low-income, our results remain relevant to the growing picture of vaccine hesitancy among at-risk groups (McCabe et al., 2021).

Non-healthcare essential workers in public transportation, many of whom are older adults and therefore more vulnerable to COVID-19, have been forced to serve on the frontlines to maintain cities’ operability and infrastructure during a dangerous pandemic. It is vital to understand their attitudes and behaviors toward protective health measures such as vaccination to protect them and their communities from COVID-19 and future biohazards.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Research reported in this publication was supported by the National Institute of Nursing Research of the National Institutes of Health under grant number 1R01NR020174-01 and by the National Institute on Aging under grant number R25AG06793101. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

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