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Perceived medical care quality during COVID-19 illness links socioeconomic disadvantage to vaccine hesitancy

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\begin{abstract}
Maximizing vaccine uptake is critical for the optimal implementation of COVID-19 immunization programs. Indicators of socioeconomic status (SES) have been associated with variations in COVID-19 vaccine uptake in the United States. The present study investigates COVID-19 vaccination behavior in individuals with history of COVID-19 infection, with the specific goal of understanding whether experiences during illness explain socioeconomic disproportionalities in vaccine uptake. We leveraged a large sample of adults (n = 1584) infected with COVID-19 in NYC to examine this question, investigating whether specific experiences during illness explained the association between socioeconomic status and COVID-19 vaccine hesitancy. Data from this study were collected during February and March 2021. Principal component analysis was used to create three composite variables that measure distinct COVID-19 related experiences: infection-related health impacts, pandemic-related psychosocial disruption, and perceived quality of medical care during COVID-19 illness. Neither infection-related impacts nor psychosocial disruption were related to vaccine hesitancy after adjusting for related sociodemographic covariates. However, perceptions of higher quality care received during COVID-19 illness predicted decreased COVID-19 vaccine hesitancy. Furthermore, mediation analysis revealed that perceived care quality during COVID-19 illness mediate the relationship between objective socioeconomic risk and COVID-19 vaccine hesitancy. These findings highlight patient-reported care quality during illness as a novel target that may increase vaccine uptake among socioeconomically vulnerable populations.
\end{abstract}

\section{1. Introduction}

Population-level uptake of vaccines serves the dual purpose of curtailing pathogen spread and decreasing rates of serious illness. The COVID-19 vaccine has been a prime example of this (Rotshild et al., 2021). However, like many other vaccines, the COVID-19 vaccine has variable efficacy across individuals and over time (Rosenberg et al., 2022), and is not universally accepted by the population (Andrews et al., 2022; Mattiuzzi and Lippi, 2022). Isolating factors that contribute to differential uptake of the vaccine is a critical imperative, both in terms of addressing immediate public health needs and for facing future health epidemics. Prevalence of health epidemics is increasing with population growth and climate change (Garrett and Lewis, 2007; The Lancet Microbe, 2021). We can thus regard the current pandemic as a moment of opportunity, where focus on population health behavior can inform future public strategy.

Studies assessing variability in COVID-19 vaccine uptake have identified cultural and demographic context as important drivers of individual health behaviors and decision making. While roughly 85% of the U.S. adult population has received at least one dose of COVID-19 vaccine as of late March 2022, rates remain lower amongst certain subpopulations, such as those without health insurance (73%) or who are below the poverty line (78%) (https://covid.cdc.gov/covid-data-tracker/). Vaccine hesitancy has been proposed as a major determinant of these disproportionalities. Indeed, vaccine hesitancy has been associated with indicators of socioeconomic status (SES) such as lower education and household income (Joshi et al., 2021; Lin et al., 2020; Moola et al., 2021; Prickett et al., 2021; Wang and Liu, 2022).

Research conducted prior to the COVID-19 pandemic highlights that vaccine hesitancy in general can partly result from distrust of the medical system. Parents who report mistrust in their healthcare providers also have more concerns about vaccine safety in children (Gilbert...
et al., 2021; Shui et al., 2006). This association is particularly pronounced among individuals living below the poverty line (Hill et al., 2017; Richardson et al., 2012; Wu et al., 2008). Decreased trust in healthcare providers among low SES individuals results from a myriad of factors, including feeling unheard or misunderstood by providers, perceptions of receiving lower quality care on account of socioeconomic status, history of institutional marginalization, and lack of diverse racial and ethnic representation in the medical system (Arpey et al., 2017; Randolph et al., 2020). The COVID-19 pandemic has disproportionately impacted low SES populations in terms of health outcomes and economic hardship, which may have further exacerbated distrust in medical and government systems. (Barry et al., 2021; Benton et al., 2021; Khanijahani et al., 2021).

There is much to learn about vaccine hesitancy and socioeconomic risk in the specific context of the COVID-19 pandemic. Here, we leverage data from the Novel Coronavirus Patient Report (NCIPR) study, a survey of >2,000 adults in New York City who contracted COVID-19 between March–December 2020 (Thompson et al., 2022). First, we sought to replicate prior work linking lower SES to greater vaccine hesitancy (Baily et al., 2021; Khubchandani and Macias, 2021). Next, we evaluated experiences during the pandemic that may have affected attitudes and behaviors regarding COVID-19 vaccination. We specifically tested whether illness severity, changes in social support during the pandemic, or perceived quality of medical care mediate the relationship between SES and vaccine hesitancy. Our overall goal is to contribute unique insight about predictors of differential vaccine uptake, with potential translational value for future public health strategies that address disproportionalities in vaccine coverage.

2. Methods

2.1. Data source

The 2021 Novel Coronavirus Illness Patient Report (NCIPR) is an open-access dataset of adults who were diagnosed with COVID-19 between March–December 2020 (Thompson et al., 2022). Potential participants who had previously consented to be contacted for research purposes were identified via ICD diagnosis code in the electronic medical record of a multicenter healthcare system in New York City. Invitations were sent by email and data were collected via online survey. Distributed between February 23, 2021, and April 4, 2021, NCIPR aggregates first-person accounts of COVID-19 illness experience, with targeted questions about COVID-19 symptoms and severity, lasting effects, anxiety about illness, employment impacts, and attitudes towards vaccination.

2.2. Ethical approval

The research protocol for this study was approved by the NYU Langone Institutional Review Board (IRB) and data were collected in compliance with the Helsinki Declaration. Only patients who had previously consented to be contacted about research opportunities were eligible for invitation to the study. Participants provided consent to share de-identified survey data for research purposes.

2.3. Study sample

The full NCIPR contains 2,212 individual responses, but 628 cases were excluded from analysis due to incomplete data (n = 483), respondent denial of COVID-19 illness (n = 65), and inconsistent response patterns (n = 80). The final sample for analysis therefore includes 1,584 cases that passed data validation (Thompson et al., 2022). The study population lived within the greater New York City metropolitan area, and were predominately female, white, highly educated, and slightly older than the local average. Detailed demographic information for the study sample is included in Table 1.

Table 1

| Sociodemographic descriptive statistics of NCIPR study population. |
|------------------|-------------------|
| Age in years     | N = 1584          |
| Education        | Mean ± SD or N (%)|
| Less than 10th grade | 5 (3.3 %)        |
| 10th-12th grade  | 8 (0.5 %)         |
| High school degree/GED | 77 (5.0 %)       |
| Trade school/apprenticeship | 30 (1.9 %) |
| Partial college  | 141 (9.1 %)       |
| 2-year college degree | 117 (7.6 %)     |
| 4-year college degree | 548 (35.5 %)    |
| Graduate degree  | 618 (40.9 %)      |
| Gender           |                  |
| Female           | 1115 (70.4 %)     |
| Male             | 465 (29.4 %)      |
| Non-binary       | 3 (0.2 %)         |
| Race/Ethnicity   |                  |
| White            | 994 (66.4 %)      |
| Hispanic/Latin   | 164 (10.9 %)      |
| Black/African American | 121 (8.1 %) |
| Asian            | 120 (8.0 %)       |
| Mixed            | 76 (5.1 %)        |
| Other            | 19 (1.2 %)        |
| Native American/Native Alaskan | 4 (<0.1 %) |
| Native Hawaiian/Pacific Islander | 0 (0 %) |
| Poverty risk score | 0 ± 2.21       |
| Perceived socioeconomic status | 0 ± 2.41 |
| Discrimination frequency | 2.56 ± 1.42 |
| Discrimination stress | 2.07 ± 0.95 |
| History of mood or anxiety disorder(s) | 288 (18.2 %) |
| Has a pre-existing health comorbidity* | 773 (48.9 %) |

Note: NCIPR respondent demographics after data validation. poverty risk score and perceived socioeconomic status are composite variables comprised of standardized summations of multiple variables (listed in 2.4). Higher poverty risk score values indicate lower ‘objective SES’, and high perceived SES values indicate higher perceived SES. Discrimination frequency was evaluated on a 7-point Likert-type scale, and discrimination stress was evaluated on a 4-point scale (not at all/a little/somewhat/extremely stressful), with higher values indicating higher frequency and greater stress. ‘Health comorbidity variable includes heart disease or hypertension, respiratory problems, diabetes, cancer, lung disease, and liver disease.

2.4. COVID-19 vaccine hesitancy

Given that vaccines were not yet readily available to the public at the time of survey administration, the primary outcome for the study is self-reported COVID-19 vaccine hesitancy. Defined as “delay in acceptance or refusal of vaccination despite availability of vaccination services”, vaccine hesitancy is influenced by factors such as complacency, convenience, and confidence (MacDonald, 2015). The wording of study measures implied imminent availability of COVID-19 vaccination services, allowing us to examine COVID-19 vaccine hesitancy despite incomplete availability of the COVID-19 vaccine at the time of survey administration (AJMC Staff, 2021). In the NCIPR survey, respondents were asked (1) “at this time have you received a COVID-19 vaccine?”, with response options “yes,” “no,” and “unsure”. Individuals who responded “no” were then asked (2) “if you were offered the COVID vaccine tomorrow, what would you do?”, with response options: “I would definitely choose to get vaccinated,” “I would probably choose to get vaccinated,” “I would probably choose NOT to get vaccinated,” and “I would definitely choose NOT to get vaccinated”. We categorized those who responded “yes” to (1) or “I would definitely choose to get vaccinated” or “I would probably choose to get vaccinated” to (2) as COVID-19 vaccine non-hesitant. Those who responded “no” to (1) and “I would probably choose NOT to get vaccinated” or “I would definitely choose NOT to get vaccinated” to (2) were classified as COVID-19 vaccine hesitant. Individuals who responded “unsure” to (1) (n = 3) were excluded from analyses.
2.5. COVID-19-specific experiences

COVID-19-specific experiences were evaluated with questions about changes in stress, sleep, daily energy levels, and social support during the pandemic, anxiety about being ill with COVID-19, life disruption following illness, number of lasting health changes following COVID-19 infection, and perceived quality of medical care received while ill with COVID-19. A composite variable reflecting COVID-19 illness severity was computed by standardizing and averaging fever severity, illness length, self-reported illness severity, medical complications, and whether the individual was hospitalized, in line with prior research (Thomason et al., 2021). All measures were coded so that higher values indicated more negative impacts (i.e., more life disruption due to COVID-19 outbreak, worse quality of care received during COVID-19 illness).

2.6. Socioeconomic status

We created two metrics of SES: objective and perceived SES. Poverty risk score, a measure of objective SES, was generated by summing standardized values of the following variables: household income-to-needs ratio, education level, stability of housing, and receipt of public assistance. Higher poverty risk score values represent lower objective SES. A measure of perceived SES was calculated by standardizing and summing survey items reflecting financial satisfaction, perceived financial stability, and the MacArthur ladder of perceived social standing. Higher perceived SES values represent a higher perception of one’s SES. Standardization of the components for each composite variable was achieved with z-scoring, and the fit of these composite variables was confirmed via confirmatory factor analyses in prior research (Thomason et al., 2021).

2.7. Sociodemographic factors

We examined associations between COVID-19 vaccine hesitancy and the following sociodemographic factors: age, race (BIPOC [Black, Indigenous, and people of color] vs non-BIPOC), self-identified gender, presence of health comorbidities, and experiences of discrimination.

2.7.1. Health comorbidities

A dichotomous variable was created for health comorbidities that classified respondents as comorbidity positive if they declared a history of any of the following conditions: respiratory problems (e.g., asthma, tuberculosis), diabetes, heart disease or hypertension, lung disease, liver disease, cancer, or a disease compromising the immune system. Respondents were classified as comorbidity negative if they did not indicate a history of any of these conditions. Self-reported history of mood/anxiety disorder(s) was considered as a separate dichotomous variable.

2.7.2. Discrimination

Subjective experiences of discrimination were assessed using two questions from the Perceived Discrimination Scale (Williams et al., 1997). Discrimination frequency was assessed with the question “in your day-to-day life, have you experienced discrimination?”. Response options were on a 7-point Likert-type scale ranging from “never” to “almost every day”. Discrimination stress was assessed with the survey question “over your entire lifetime, how stressful have experiences of unfair treatment or discrimination usually been for you?”, with response options on a 4-point Likert-type scale ranging from “not at all stressful” to “extremely stressful”.

2.8. Statistical approach

2.8.1. Evaluation of socioeconomic associations to COVID-19 vaccine hesitancy

We evaluated the association between SES and COVID-19 vaccine hesitancy. We also explored whether COVID-19 vaccine hesitancy associated with sociodemographic factors listed in 2.7, including health comorbidities and experiences of discrimination. All factors were entered into a binomial logistic regression model with COVID-19 vaccine hesitancy as the outcome variable. Sociodemographic factors that were significantly associated with COVID-19 vaccine hesitancy in this omnibus regression were included as covariates in subsequent analyses.

2.8.2. Factor analysis of COVID-19-specific experiences

An exploratory principal component analysis (PCA) with varimax (orthogonal) rotation was used to reduce data into latent variables that described patient COVID-19 related impacts. The number of components was determined by examining scree plots, and the model with the greatest number of components with an eigenvalue > 1 was selected as the final model (Jolliffe, 2011).

2.8.3. Hierarchical addition of COVID-19-specific experiences to socioeconomic regression model predicting COVID-19 vaccine hesitancy

Binomial logistic regressions were used to evaluate the effect of COVID-19-specific experiences as predictors of COVID-19 vaccine hesitancy, after adjusting for SES and sociodemographic covariates. We then used the PROCESS macro (Hayes, 2013) to determine whether identified relationships between COVID-19 vaccine hesitancy and SES were mediated or moderated by COVID-19-specific experiences.

Statistical analyses were carried out using SPSS version 25 and replicated using the psych (Revelle, 2021), processR (Keon-Woong, 2021), rcompanion (Salvatore, 2022), stats, and tidyeverse (Wickham et al., 2019) packages in RStudio 1.4.1717 (Rstudio Team, 2020).

3. Results

3.1. Sample description

Fig. 1 demonstrates NCIPR respondent vaccination status and hesitancy at the time of survey administration in February 2021. At this time, 815 (54 %) of respondents had received at least one dose of the COVID-19 vaccine, and 730 (46 %) had not received any. Of those who had not received any vaccine doses, 507 (69 %) indicated that they would probably (n = 129) or definitely (n = 378) choose to get vaccinated “if they were offered the vaccine tomorrow”; and 227 (31 %) indicated that they would probably (n = 156) or definitely (n = 71) choose not to be vaccinated “if offered tomorrow”. Final sample respondent demographics are in Table 1.

3.2. Aim 1: Association of SES with COVID-19 vaccine hesitancy

As shown in Table 2, both objective and perceived SES were significantly associated with COVID-19 vaccine hesitancy. Individuals with

![Fig. 1. NCIPR respondent vaccination status (left), and unvaccinated respondents’ intent to vaccinate (right).](image-url)
lower perceived SES, in addition to those with increased poverty risk score (thereby lower objective SES) were more likely to be COVID-19 vaccine hesitant. Sociodemographic covariates were also identified: younger respondents, respondents of female gender, respondents with prior history of mood or anxiety disorder(s) were more likely to be COVID-19 vaccine hesitant.

### 3.3. Aim 2: Association of COVID-19-specific experiences with COVID-19 vaccine hesitancy

#### 3.3.1. Derivation of COVID-19-specific experiences

PCA revealed a 3-component model to be the best fit (60.3 % cumulative explained variance). The three extracted components did not have significant cross-loadings and were theoretically feasible. Individual factor loadings can be viewed in Table 3.

The first component represents \textit{infection-related impacts}, including life disruption due to infection, illness severity, anxiety about being ill, and number of lasting symptoms following infection. The second component represents \textit{pandemic psychosocial impacts}, including worsened sleep, daily energy, social support, stress and mental health. \textit{Perceived quality of medical care} received during COVID-19 infection loaded onto its own component, with higher scores reflecting worse quality of care.

#### 3.3.2. Main effects of COVID-19-specific experiences

Neither infection-related impacts nor pandemic psychosocial impacts were significantly associated with likelihood of being vaccine hesitant after controlling for poverty risk score, perceived SES, age, and gender, and history of mood or anxiety disorder(s). However, worse perceived quality of medical care received during COVID-19 infection was associated with an increased likelihood of being COVID-19 vaccine hesitant, even after adjusting for sociodemographic covariates (Table 4).

#### 3.3.3. Mediation and moderation analyses

Mediation analysis demonstrated that greater poverty risk was associated with worse perceived quality of medical care received during COVID-19 illness (Fig. 2, path A). In turn, individuals who reported worse perceived quality of care were also more likely to be COVID-19 vaccine hesitant (Fig. 2, path B). The indirect effect of poverty risk on

### 4. Discussion

Among New York City residents with a history of COVID-19 infection, increased COVID-19 vaccine hesitancy was associated with low perceived and objective socioeconomic status, as well as female gender, younger age, and reported history of mood or anxiety disorder(s). These associations are consistent with extant literature that has demonstrated decreased COVID-19 vaccination rates and increased vaccine hesitancy in young, female, and low SES populations (Barry et al., 2021; Daly et al., 2021; Joshi et al., 2021; Khubchandani and Macias, 2021; Lin et al., 2020; Moola et al., 2021; Prickett et al., 2021; Wang and Liu, 2022). Moreover, we identified a specific experience during the pandemic that partially explained the noted association between lower SES and vaccine hesitancy: perceived quality of medical care received during COVID-19 illness.

Sociodemographic variations in COVID-19 vaccine attitudes may be partially explained by the disproportionate impact of the pandemic on low SES individuals and other marginalized groups. Objective indicators

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### Table 2

| Outcome: COVID-19 Vaccine Hesitancy | B   | SE  | Wald | OR  | 95% CI (OR) | p   |
|-------------------------------------|-----|-----|------|-----|-------------|-----|
| Age                                 | -0.03 | 0.01 | 11.95 | 0.98 | 0.96 - 0.99 | 0.001 |
| Race (BIPOC vs non-BIPOC)           | -0.20 | 0.22 | 0.89  | 0.82 | 0.53 - 1.25 | 0.345 |
| Poverty risk score                  | 0.16  | 0.04 | 15.20 | 1.17 | 1.08 - 1.26 | 0.000 |
| Gender (Female vs Male)             | -0.44 | 0.22 | 3.87  | 0.64 | 0.41 - 0.99 | 0.049 |
| Discrimination frequency            | 0.08  | 0.07 | 1.30  | 1.09 | 0.94 - 1.26 | 0.254 |
| Discrimination stress               | -0.24 | 0.12 | 3.79  | 0.79 | 0.62 - 1.00 | 0.052 |
| Perceived SES                       | -0.09 | 0.04 | 4.28  | 0.92 | 0.85 - 0.99 | 0.038 |
| History of mood or anxiety disorder(s) | 0.54 | 0.25 | 4.57  | 1.70 | 1.04 - 2.78 | 0.033 |
| Presence of health comorbidities    | -0.15 | 0.20 | 0.52  | 0.87 | 0.58 - 1.29 | 0.469 |

Note: SE = standard error. OR = odds ratio. LL = lower limit. UL = upper limit. Nagelkerke $R^2 = 0.10$

### Table 3

| Variables                  | Infection-Related Impacts | Pandemic Psychosocial Impacts | Perceived Medical Care Quality During Illness | Communality |
|----------------------------|---------------------------|-------------------------------|---------------------------------------------|-------------|
| Infection-related impacts  |                           |                               |                                             |             |
| Life disruption            | 0.78                      |                               |                                             | 0.64        |
| Illness anxiety            | 0.56                      |                               |                                             | 0.46        |
| Lasting symptom count      | 0.69                      |                               |                                             | 0.53        |
| Mental health              |                           |                               |                                             |             |
| Outbreak effects on stress | 0.73                      |                               |                                             | 0.58        |
| Outbreak effects on sleep  | 0.35                      |                               |                                             | 0.59        |
| Outbreak effects on daily energy | 0.65 |                               |                                             | 0.42        |
| Outbreak effects on social support |         |                               |                                             |             |
| Perceived quality of care during illness | 0.96 |                               |                                             | 0.92        |

Note: Aim 2 principal components analysis (PCA) variable-factor loadings. Three theoretically feasible components represent infection-related impacts, pandemic psychosocial impacts, and perceived medical care quality during infection. Loadings < 0.3 were omitted for clarity.

COVID-19 vaccine hesitancy was significant (Fig. 2, $b = -0.01$, 95 % CI [-0.02, -0.002]), suggesting mediation by perceived quality of care after adjustment for age, gender, perceived SES, and history of mood or anxiety disorder(s). We next evaluated whether COVID-19-specific experiences moderated the association between poverty risk score and vaccine hesitancy. The association between poverty risk score and vaccine hesitancy was not moderated by COVID-19-specific illness impacts, pandemic psychosocial impacts, or perceived quality of medical care received during COVID-19 illness after controlling for gender, age, perceived SES, and history of mood or anxiety disorder(s) (Table 5).
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of SES, including education level, housing conditions, and household income have been negatively associated with greater economic impact due to the pandemic as well as higher risk of infection, hospitalization, and death due to COVID-19 (Barry et al., 2021; Benton et al., 2021; Khanijahani et al., 2021). These relationships have been consistently demonstrated in the literature despite variation in how SES is measured; furthermore, these socioeconomic associations have been implicated in noted racial and ethnic disparities in COVID-19 vaccination and health outcomes, acknowledging the complex interplay between SES, health outcomes, and race (Agarwal et al., 2021; Khubchandani and Macias, 2021; Williams et al., 1997). Put together, it seems that pre-existing socioeconomic disparities have been exacerbated by COVID-19’s disproportionate impact on vulnerable populations, leading to fundamental differences in how the pandemic has been experienced, stratified by social standing.

Our findings suggest that one such way in which the pandemic was differentially experienced by low SES individuals was in worse perceptions of care quality, which explained significant variance in hesitant vaccine attitudes. This isolates the improvement of patient-perceived care quality during illness treatment as a potential target for addressing socioeconomic disparities in vaccine coverage. Perceived care quality plays an important role in the development of patient-provider trust, as well as in illness outcomes and future health behaviors (Marjoua and Bozic, 2012). For example, patient-provider relationships have positively influenced the health outcomes of Black cancer survivors via positive perceptions of care quality (Asare et al., 2020). In our own findings, less-than-excellent perceived care quality was more commonly reported by lower SES respondents and may have been more generally demonstrated in the literature despite variation in how SES is measured; indicating the presence of partial mediation of the relationship between poverty risk score and COVID-19 vaccine hesitancy. Analyses control for age, gender, perceived SES, and history of mood or anxiety disorder(s).

Table 4
Hierarchical regression models for COVID-19-specific experiences.

| Outcome: COVID-19 Vaccine Hesitancy | β | SE | Wald | OR | 95 % CI (OR) | p | R² |
|-------------------------------------|---|----|------|---|-------------|---|---|
| Model 1: Infection-related impacts   |   |    |      |   |             |   | 0.08 |
| Poverty risk score                  | 0.10 | 0.04 | 8.365 | 1.11 | [1.03, 1.19] | 0.004 |   |
| Gender                              | −0.58 | 0.04 | 7.975 | 0.56 | [0.37, 0.84] | 0.005 |   |
| Perceived SES                       | −0.07 | 0.04 | 4.187 | 0.93 | [0.87, 0.99] | 0.041 |   |
| Age                                 | −0.03 | 0.01 | 18.61 | 0.97 | [0.96, 0.99] | <0.001 |   |
| History of mood/anxiety disorder(s) | 0.57 | 0.2 | 6.176 | 1.76 | [1.13, 2.75] | 0.013 |   |
| Infection-related impacts           | 0.06 | −0.09 | 0.399 | 1.06 | [0.89, 1.25] | 0.528 |   |
| Model 2: Pandemic psychosocial impacts |   |    |      |   |             |   | 0.08 |
| Poverty risk score                  | 0.11 | 0.04 | 9.08 | 1.11 | [1.04, 1.19] | 0.003 |   |
| Gender                              | −0.60 | 0.21 | 8.53 | 0.55 | [0.37, 0.82] | 0.003 |   |
| Perceived SES                       | −0.09 | 0.04 | 5.62 | 0.92 | [0.85, 0.99] | 0.018 |   |
| Age                                 | −0.03 | 0.01 | 18.30 | 0.97 | [0.96, 0.99] | 0.000 |   |
| History of mood/anxiety disorders   | 0.53 | 0.23 | 5.49 | 1.70 | [1.09, 2.66] | 0.020 |   |
| Pandemic-related psychosocial impacts | −0.09 | 0.09 | 1.07 | 0.92 | [0.77, 1.08] | 0.302 |   |
| Model 3: Perceived quality of care  |   |    |      |   |             |   | 0.09 |
| Poverty risk score                  | 0.12 | 0.04 | 10.87 | 1.13 | [1.05, 1.21] | 0.001 |   |
| Gender                              | −0.56 | 0.21 | 7.45 | 0.57 | [0.38, 0.85] | 0.006 |   |
| Perceived SES                       | −0.07 | 0.04 | 3.34 | 0.94 | [0.87, 1.01] | 0.068 |   |
| Age                                 | −0.02 | 0.01 | 13.87 | 0.98 | [0.97, 0.99] | 0.000 |   |
| History of mood/anxiety disorders   | 0.60 | 0.23 | 6.89 | 1.83 | [1.16, 2.86] | 0.009 |   |
| Perceived quality of care           | 0.23 | 0.08 | 16.93 | 1.25 | [1.07, 1.47] | 0.006 |   |

Note: Binomial linear regressions of sociodemographic factors on COVID-19 vaccine hesitancy, with stepwise additions of COVID-19-specific experiences. Nagelkerke R² represents total estimated variance explained by the model. All regressions control for poverty risk score, gender, perceived SES, age, and history of mood/anxiety disorders. COVID-19-specific experiences that were significantly associated with COVID-19 vaccine hesitancy are denoted in bold. Of the COVID-specific experiences, worse perceived quality of care was associated with an increased likelihood of being COVID-19 vaccine hesitant.

Table 5
Moderation analyses of COVID-19-specific experiences on the relationship between poverty risk score and COVID-19 vaccine hesitancy.

| Model | β | 95 % CI for β | SE | p | 1 Vaccine hesitancy − poverty risk + infection impacts | 0.004 | −0.05 | 0.06 | 0.03 | 0.884 |
|-------|---|---------------|----|---|------------------------------------------------------|-------|-------|-------|-------|-------|
|       |   |               |    |   | 2 Vaccine hesitancy − poverty risk + psychosocial impacts | −0.004 | −0.06 | 0.05 | 0.03 | 0.883 |
|       |   |               |    |   | 3 Vaccine hesitancy − poverty risk + perceived care quality | 0.02 | −0.04 | 0.08 | 0.03 | 0.572 |

Note: Moderation analyses were performed using the PROCESS package (Hayes, 2013). All models controlled for age, gender, perceived socioeconomic status, and history of mood or anxiety disorder(s). p’s > 0.05 and 95 % confidence intervals crossing 0 indicate no moderation of relationship between poverty risk score and COVID-19 vaccine hesitancy by COVID-19-specific illness impacts, pandemic psychosocial impacts, or perceived care quality.
same recommendations from a practitioner that delivered low quality care.

The perception of care quality is comprised of a complex interplay of cultural, temporal, individual, and population level factors; i.e., the relative weights of patient experiences that make up “high quality” care change from place to place and from person to person. Nevertheless, the World Health Organization argues that patient-reported quality measures are integral drivers of acceptability and responsiveness to health recommendations and levels of patient-provider trust, which in turn are critical for increasing health service utilization and adherence to public health policy (Hanefeld et al., 2017). If we are to increase public acceptance of COVID-19 vaccination, it is important to identify ways in which the healthcare community can strive to ensure that every patient feels that they are receiving the best care possible, not only because it may impact the outcome of their current illness, but their future health behaviors as well.

There are numerous strategies identified in the literature to improve patient-reported care quality. One such example is increasing the use of patient-centered communication, which has been shown to improve patient-reported health outcomes and perceived care quality in US patients (Pozzar et al., 2021). Furthermore, the incorporation of a ward-round checklist (similar to a peri-operative checklist) into post-surgical unit daily workflow may increase patient understanding of their diagnosis and treatment plan as well as patient perceptions of care quality (Read et al., 2021). Finally, a series of semi-structured internet interviews conducted by Ipsos identified three major mechanisms by which hospitals build patient trust: competence (e.g., effective treatments conducted by Ipsos identified three major mechanisms by which hospitals build patient trust: competence (e.g., effective treatment, environmental cleanliness, knowledgeable clinicians), caring (e.g., prioritizing patient comfort, welcoming environment, compassionate clinicians), and communication (e.g., listening to patients, clear treatment and discharge plans) (Greene and Samuel-Jakubos, 2021). Of note, many of these strategies for improving perceived care quality are tied to clear and empathic communication between patient and healthcare team. This knowledge can be leveraged by hospitals in low SES areas to develop patient-centric quality improvement initiatives that examine and respond to the specific communicative and environmental needs of their patient populations.

It is important to note that the NCIPR sample is not representative of the larger New York City population, but is instead disproportionately female, White, wealthy, and highly educated; the relatively high levels of wealth and education in the sample are an important reminder that measures of “low SES” in this study were not absolute, but relative to the rest of the sample. The NCIPR population was also recruited from a single healthcare institution, likely limiting the range of care quality experienced. The observed association between socioeconomic status and vaccine hesitancy would likely be stronger if examined in a sample with greater variability in income and healthcare experience. This suggests that the present study may in fact underestimate the importance of care quality in socioeconomically disadvantaged groups. Future studies with nationally representative samples are therefore needed.

Vaccine attitudes were measured during a specific time in the pandemic when access to and information about the long-term efficacy of COVID-19 vaccinations were still limited. In early 2021, COVID-19 vaccines had not yet received full FDA approval and vaccine access was not yet guaranteed for all US adults (AJMC Staff, 2021). As such, the NCIPR dataset represents a unique time in the pandemic, a time of heightened uncertainty about the vaccine for much of the public. It is possible that in times of such uncertainty, individuals may more heavily weigh prior experiences with the medical system to calculate health behaviors. It is unclear how the changing COVID-19 pandemic landscape would alter the present findings, especially given that more information about long-term vaccine efficacy and safety is now available; multiple vaccines are now available under full FDA approval in the United States as well, and approval has been extended to children as young as 6 months of age (https://www.cdc.gov/coronavirus/2019-ncov/vaccines/different-vaccines/overview-COVID-19-vaccines.html). If our findings are replicated in present times, this further underscores the importance of implementing patient-centric quality improvement measures in healthcare systems that serve low SES populations. Otherwise, the effect of care quality perceptions on vaccine behavior may be especially salient during times of medical and social uncertainty.

In conclusion, increasing COVID-19 vaccine uptake in high-risk populations remains critically important for pandemic control. This study implicates patient perceptions of care quality as an important target for improving vaccine coverage, particularly in low SES populations that have been disproportionately impacted by the pandemic. Furthermore, as repeated booster shots are becoming a more common recommendation, COVID-19 vaccine hesitancy may continue to be a serious detriment to pandemic control. To address this as a healthcare system, we suggest increased attention and resource allocation towards understanding and improving aspects of our patients’ experiences that inform their perceptions of care quality. Indeed, improving patient perceptions of care in populations that have been historically marginalized may have far reaching effects beyond COVID-19 vaccine uptake, including better clinical outcomes, stronger patient-provider relationships, and increased trust in the medical system.

CRedit authorship contribution statement

Nils Kjos: Conceptualization, Investigation, Visualization, Formal analysis, Writing – original draft. Cassandra L. Hendrix: Methodology, Investigation, Formal analysis, Supervision, Validation, Writing – review & editing. Moriah E. Thomason: Conceptualization, Methodology, Writing – review & editing, Investigation, Supervision, Funding acquisition, Data curation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Data and materials availability

All data have been made publicly available and curation/validation processes have been documented. Please refer to https://pubmed.ncbi.nlm.nih.gov/34100021/ for documentation about validation/curation and refer to https://osf.io/82rkj/wiki/home/ for data; License: CC-By Attribution 4.0 International.
