Association of Neighborhood Disadvantage and COVID-19 and Influenza Vaccine Uptake and Positivity Among Kaiser Permanente Washington Flu Vaccine Effectiveness Subjects, 2018 - 2022

Magali Sanchez

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Karen J. Wernli

Rachel Winer

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Magali Sanchez

University of Washington

Abstract

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Magali Sanchez

Chair of the Supervisory Committee:

Karen J. Wernli

Departments of Epidemiology and Health Systems and Population Health

Neighborhoods with high Area Deprivation Index (ADI) scores have been linked to an increased risk of viral transmission and lower vaccine uptake. Subsequently, ADI has informed public health efforts and interventions at the neighborhood level, especially in the context of the COVID-19 pandemic. Understanding granular patterns and disparities in vaccine uptake and viral transmission is crucial for mitigating future outbreaks and allocating resources effectively. Further, gaining insights into the association between ADI and viral outcomes could provide valuable guidance on whether future studies on vaccine effectiveness should consider ADI as a significant confounding factor. This study examined the relationship between ADI and influenza and COVID-19 vaccine uptake and test positivity, utilizing individual-level data from the U.S. Influenza Vaccine Effectiveness Network (FluVE) studies conducted at Kaiser Permanente in Washington (KPWA) between 2018 and 2022. Subjects were categorized into low or high-

disadvantaged neighborhoods based on their residential addresses, and outcomes were assessed using baseline surveys, electronic health records, and laboratory results.

The overall study population included 6,092 subjects over 18 years old divided into two analysis cohorts: Influenza and COVID-19. Multivariate logistic regression analyses indicated that ADI was associated with COVID-19 vaccine uptake (Odds Ratio [OR]: 0.89; 95% Confidence Interval [CI]: 0.71, 1.10) but not influenza vaccination (OR: 1.03, 95% CI: 0.89, 1.18), influenza positivity (OR: 1.16, 95% CI: 0.99, 1.37) or COVID-19 positivity (OR: 0.89, 95% CI: 0.71, 1.10). Subjects living in high disadvantaged neighborhoods had lower odds of being fully vaccinated against COVID-19 compared to individuals in low disadvantaged neighborhoods. Overall, findings suggest that neighborhood deprivation as measured by ADI is still important for emergent vaccine rollouts. ADI was not a confounder in estimates of influenza vaccine effectiveness. As new vaccines are developed and distributed, future public health emergency and Advisory Committee on Immunization Practices policies should include considerations to prioritize resources and focus on disadvantaged areas.

Background and Significance

The outbreak of the novel coronavirus disease (COVID; COVID-19; SARS-CoV-2) in 2019 led to significant global infection and mortality rates, highlighting disparities in disease burden among marginalized and low-income populations and emphasizing the need to prioritize the elimination of these disparities and how these patterns could help public help officials effectively prioritize marginalized communities. [1,2] As the pandemic shifts into a new "normal", the need to better understand patterns in the transmissibility of viral respiratory infections becomes more important to prevent or mitigate future outbreaks, in particular how social determinants of health influence health disparities, and could prioritize marginalized communities. [3] For more than a decade, the Centers for Disease Control and Prevention (CDC) have invested in the surveillance of influenza vaccine effectiveness (VE) to inform public health policy through the U.S. Influenza Vaccine Effectiveness Network (FluVE).[4] The study was primarily designed to evaluate influenza vaccine effectiveness in ambulatory patients by age group, virus type and subtype. However, the network shifted to incorporate COVID-19 incidence and vaccine effectiveness as a result of the pandemic. Kaiser Permanente Washington (KPWA), one of the seven study sites in the Network, is well positioned to surveil influenza and COVID year-round. Every year, KPWA enrolls between 1,200 to 1,700 individuals between the ages of 6 months to over 65 years into the FluVE study.

Continual surveillance is important for planning for future seasons of viral respiratory infections and targeted interventions to curtail spread and implement vaccination strategies. Additionally, with the emergence of new vaccines and evolving vaccination behaviors, updated analytic methods and the inclusion of measures on social determinants of health will be vital. This is crucial for the development of public health campaigns that address disparities in vaccination and infection rates at the community levels.

Prior vaccine effectiveness studies use a test-negative study design and minimally adjust for confounders, namely age, high-risk status, calendar time, and sex.[5] Social determinants of health encompass a wide range of socioeconomic factors on an individual-level, such as household size, education, income, and race and ethnicity[6]. Individual characteristics, such as sex, high-risk health status, rurality and income, have been shown to be associated with lower COVID-19 and influenza vaccine adherence and higher disease prevalence.[7–9] While individual socioeconomic status influences certain health outcomes, neighborhood composite measures, ideally at census tract levels, are also useful for understanding broader viral transmission within communities.[3,10]

Originally developed in 1990 by the Health Resources and Services Administration, the area deprivation index (ADI) score, is a composite measure of socioeconomic status by census tract.[11] It is composed of 17 socioeconomic measures, including education, employment, housing and poverty drawn from recent American Community Survey data.[12] ADI scores are available for all census tracts across the United States. The ADI score is an ideal measure that incorporates multiple socioeconomic factors at a geographically small unit of analysis. While there are limited studies on the role of ADI on respiratory viruses prior to the pandemic, studies found that individuals residing in neighborhoods with higher ADI scores (i.e., greater deprivation) had a higher risk of contracting COVID and highlighted factors that increased transmission.[3,7] ADI scores have also been used to advise public health efforts and interventions at a neighborhood level, particularly with COVID vaccine allocation.[13,14] From a public health perspective, the development of health campaigns could benefit from research to understand how ADI could be used to eliminate disparities in vaccination strategies, especially given recent trends in vaccine hesitancy.[3,13]

We conducted an observational cohort study of ADI associated with influenza and COVID-19 vaccine uptake and test positivity in KPWA subjects enrolled in US FluVE Study from 2018-2022. We aimed to test whether study subjects with higher ADI scores, or who live in more disadvantaged neighborhoods, had lower odds of vaccine uptake among this study population. Similarly, we aimed to test whether study subjects with lower ADI scores, or who live in low disadvantaged neighborhoods, had lower odds of testing positive for influenza or COVID. Results from the analysis will be relevant in understanding whether ADI is confounder in vaccine effectiveness studies broadly and locally to inform the development of strategies that lower transmission and improve vaccine uptake. The FluVE network annual influenza VE estimates are used by the Advisory Committee on Immunization Practices (ACIP) to inform annual vaccination policy and it could be important to know if ADI is an overlooked confounder for vaccination uptake. Finally, as the FDA and ACIP gather feedback regarding the streamlining of the COVID-19 immunization timetable, understanding the elements that enhance the acceptance of vaccines with comparable schedules can contribute valuable insights to the decision-making procedures.[15]

Methods

Setting

Kaiser Permanente is an integrated managed care organization with several regional entities across the United States, one of them being in Washington state. KPWA was established in 2017 (after the acquisition of Group Health), and now provides health care to approximately 450,000 members across the state.[16] KPWA has participated in the FluVE network since 2011, and the FluVE Network has been previously described in other published work on vaccine effectiveness.[17–20] The setting for participant recruitment varied before, during, and since the COVID-19 pandemic. Prior to 2020, across Western Washington, nine KPWA primary and urgent care sites participated in the collection of patient specimens in in-clinic settings. Historically, study participation was limited to in-clinic visits and during peak influenza season (November – April). However, with the worldwide emergence of COVID in late 2020 in-clinic recruitment was halted between March 2020 to 2021, and study subjects were recruited over the phone with a self-swab protocol. In January 2022, recruitment resumed from COVID-19 testing sites at two clinical testing sites until June 2022. **Figure 1** visually demonstrates data sources and data collection methods across time. The study population was restricted to enrollment from 2018-2022 to include estimates of both influenza and COVID-19 vaccine uptake and infections.

Subjects

Patients, 6 months or older, were recruited to enroll in the FluVE study if they sought outpatient or remote medical care for a chief complaint that included cough, fever or feverishness and/or loss of taste or smell in the past 9 days. However, for the purposes of this analysis, only subjects over 18 years old were included. Symptomatology, as well as time since symptom onset, was expanded to adjust for COVID-specific symptoms.[17] Eligible patients were current KPWA members at the time of enrollment. For in-clinic enrollment, staff interviewed patients to gather demographic information, symptoms, general health status, and collected nasal and/ or oropharyngeal swab specimens. Subjects recruited remotely were sent kits for self-collection of a nasal swab. Study subjects were further ineligible if their acute illness exceeded days since symptom onset or if they had taken any antiviral medications for their acute symptoms. All study procedures for patient identification, data collection and specimen processing were approved by KPWA Institutional Review boards.

Data Collection

a. Baseline Survey

KPWA FluVE study staff collected demographic information at baseline enrollment including age, race and ethnicity, education, self-reported vaccination status for influenza and COVID, and smoking status. Subjects were also asked about their symptoms, illness severity, and duration.

b. Specimen Collection

Following the baseline survey, staff collected swab specimens during in-clinic recruitment. Collected specimens were shipped to Marshfield Clinic Research Institute (MCRI) to be tested for influenza and COVID by a CLIA-certified laboratory using RT-PCR. Subjects who enrolled remotely were sent a self-swab kit similar to home antigen tests to complete a nasal swab and mailed their specimen directly to MCRI. Positive influenza specimens went through additional testing to determine subtype/lineage.

c. EHR data

Data obtained on the baseline survey were supplemented with and validated by the patient's electronic health records (EHR) and state immunization records. EHR data include patient height, weight, and historical influenza and COVID vaccines, including lot number, manufacturer, and route of administration, and information about general health and comorbidities. Lastly, self-reported vaccination data is verified against KPWA immunization data and state immunization records obtained by the Washington Immunization Information Registry (WAIIS) or validated for plausibility.

Exposure

University of Wisconsin-Madison has refined, validated, and standardized ADI to the neighborhood or Census block-group level using 17 specific U.S. Census variables and the American Community Survey (ACS) Five Year Estimates.[i] Data by Census block-group or

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[i] The 17 variables included in the calculation of the ADI are: Percentage of population aged 25 years or older with less than 9 years of education, percentage of population aged 25 years or older with less than a high school diploma, percentage of employed persons aged 16 years or older in white collar occupations, median family income, income disparity, median home value, median gross rent, median monthly mortgage, percentage of owner-occupied housing units, unemployment rate, percentage of families below the poverty level, percentage of population below 150% of the poverty threshold, percentage of single-parent households with children younger than 18 years, percentage of households without a motor vehicle, percentage of households without internet, percentage of occupied housing units without complete plumbing, and percentage of households with more than 1 person per room.

selected geographical region is readily available for download under the Neighborhood Atlas, a website created in 2018 for the purpose of sharing measures of disparity at a granular level.[11,21] ADI scores are calculated to provide rankings on two levels: national and state. ADI scores on the national level range from 1, indicating the lowest level of disadvantage, to 100, indicating the highest level of disadvantage. ADI scores on the state level range from 1 to 10 where, similarly, lower scores indicate lower levels of disadvantage. The Neighborhood Atlas allows researchers and public health departments to utilize the tool to visualize neighborhood disadvantage and rank neighborhoods against others in the same state or across the country.[11] Addresses from patients' EHR were geo-coded and assigned to an ADI score based on Version 3.2, which was calculated using 2016 to 2020 ACS 5-year estimates data. We utilized nationally ranked ADI scores in this analysis to improve the generalizability of the findings outside of Washington state.

Outcomes

We assessed four primary outcomes based on subjects' ADI categorization: influenza vaccination, influenza test positivity, COVID-19 vaccination and COVID-19 test positivity. The first set of outcomes were vaccination uptake (unvaccinated vs. vaccinated) for influenza and COVID-19 separately. Subjects were considered vaccinated against influenza if there is record of receiving a seasonal influenza shot at least 14 days prior to symptom onset. Individuals are categorized as fully vaccinated against COVID-19 if they received a single dose of the Johnson and Johnson vaccine or completed the recommended two-dose regimen of either Pfizer or Moderna, with at least 14 days elapsed from the date of enrollment. Subjects with missing vaccination records were categorized as unvaccinated. The second set of outcomes are lab results as binary variables (positive vs. negative) for influenza and COVID-19 separately. Lab results are based on reverse transcription-polymerase chain reaction (RT-PCR) tests completed at MCRI. Any influenza subtypes were categorized as positive lab results.

Covariates

Key covariates were ascertained from the baseline survey and were self-reported at enrollment or captured from the subject's EHR. Age (Ages 18-24, 25-44, 45-64, and 65 years or older), biological sex (male/ female), race (American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Pacific Islander, White or Caucasian or Other), and

ethnicity (Hispanic/ Non-Hispanic) and education (less than high school and graduated High School or GED, some college, Bachelor's degree or advanced degree) were captured as categorical variables. Additional covariates include cigarette use (every day and some days/ not at all), household exposure to smoke (daily and some days/ none) and having at least one high-risk medical condition such as such as heart or lung disease, diabetes, cancer or liver failure (yes/ no).

Statistical Analysis

The primary analysis was stratified based on the years in which influenza and COVID-19 were circulating into two cohorts (**Figure 2**). Analyses on influenza outcomes were restricted to 2018-2020 study period and COVID-19 outcomes were restricted to 2020-2022 study period. The analysis on influenza was limited to these two years due to the lack of influenza activity during that time of the COVID-19 pandemic.[22] Subjects who enrolled in study years 8 and 9, and between 2018 to 2020, will henceforth be referred to as the influenza cohort, and those with a date of enrollment after November 2020 and who enrolled in study years 10 and 11 will be referred to as the COVID cohort. Descriptive statistics were used to summarize key covariates by proportions for categorial variables, and median and interquartile range for continuous variables by study population. The overall study population's median ADI score was calculated and used to categorize subjects into two levels of disadvantage: low (0 to median) and high (1-point higher than the median to 100).

We conducted univariate and multivariate logistic regressions to calculate the odds ratio (OR) between subjects' ADI category (low vs. high disadvantage), and their vaccination status and lab results for influenza and COVID-19. We created total of four models, separated by outcome (vaccination status and test positivity), and virus (COVID-19 and influenza). All multivariate models were adjusted for the key covariates (age, sex, race and ethnicity, education, smoking status, household exposure to smoke and having a high-risk medical condition). Reference groups were selected based on the largest categories in the overall study population. To ensure a complete case analysis, FluVE subjects with missing information for ADI scores, lab results and key covariates were excluded from the study. Statistical significance was set at an alpha of 0.05. RStudio (Version 2021.09.1) was used to conduct these analyses.

Results

The overall study population consisted of 6,092 adult subjects; influenza cohort included 3,897 (64.0%) subjects and COVID-19 included 2,067 (33.9%) subjects. The sociodemographic characteristics of the overall study population are presented in **Table 1**. Characteristics of the influenza and COVID cohorts are in **Tables 2 and 3** respectively. **Table 8** demonstrates the results of the univariate and multivariate output for ADI only.

The median ADI score of the overall study population was 19; subjects who had an ADI score between 0 and 19 were categorized as living in a low disadvantaged neighborhood, and those who had a score of 20 and above were categorized as living in a high disadvantaged neighborhood. Subjects who lived in high disadvantaged neighborhoods had higher percentages of subjects who were female (66.5%), under 45 years old (47.4%), Hispanic (10.3%) and who had completed less than a Bachelor's degree (59.4%). Subjects in high disadvantaged neighborhoods also had higher proportion of subjects with cigarette exposure, with 10.5% of subjects smoking every day or some days, and 18.8% of subjects with household tobacco exposure.

Influenza Cohort

The influenza cohort included 3,949 subjects enrolled between 2018 and 2020, constituting 65% of the study population. After the exclusion of patients with missing covariates data, 3,897 subjects made up the final influenza cohort (**Table 2, Figure 2**). To optimize the utilization of the study population's vaccination records, the influenza cohort was subsequently divided into two distinct groups to enable separate analysis of vaccination data and laboratory results. Following the removal of subjects with missing lab results, a total of 3,454 subjects were included in the analysis for influenza positivity.

The overall influenza study population had a median age of 49 years and were 64.2% female. The majority of cohort were White (74.6%) and 8.8% of all subjects identified as Hispanic. Moreover, less than half of the subjects (48.3%) had completed a Bachelor's or Advanced degree. Approximately 40.6% of the subjects had a high-risk health condition diagnosis within one year before enrollment. Half of all subjects had an ADI score between 10 and 33, with a median score of 20 out of 100. ADI was not associated with influenza vaccination (OR = 1.03, 95% Confidence Interval [CI] = 0.89 – 1.18) in multivariate models (**Table 4**). Patient factors associated with influenza uptake included: older age (45-64 years OR = 1.66, 95% CI: 1.42 – 1.95; 65+ years OR

= 4.74, 95% CI: 3.80 – 5.91, compared with 25-44 years old); Asian race (OR = 1.39, 95% CI: 1.09 – 1.77, compared with White race); and high-risk conditions (OR = 1.72, 95% CI: 1.48 – 1.99, compared with no high-risk conditions). Some patient factors were also associated with reduced odds of influenza vaccine uptake, including being male and having less than a Bachelor's degree. Compared to female subjects, male subjects were 22% less likely to be vaccinated (OR = 0.78; 95% CI: 0.68 – 0.90). Subjects who had not graduated high school or who had completed a high school degree were less likely to be vaccinated (OR = 0.61, 95% CI: 0.49 – 0.77 and OR = 0.72, 95% CI: 0.61 – 0.86 respectively).

ADI was also not associated with influenza positivity in multivariable models (OR = 1.16, 95% CI: 0.99 – 1.37) (**Table 5**). Native Hawaiian or Pacific Islander race (OR = 2.84, 95% CI: 1.66 – 4.85) was the only patient factor associated with increased odds of test positivity, compared to White race. Patient factors associated with decreased odds of test positivity were being older than 65 years of age (OR = 0.64, (95% CI: 0.50, 0.82) and having at least one high-risk condition (OR = 0.78; 95% CI: 0.66 – 0.94).

COVID Cohort

After the exclusion of patients with missing covariates data and test results, the COVID cohort included 2,067 subjects enrolled between 2020 and 2022 and made up 33.9% of the study population (**Table 3**). Subjects in the COVID cohort had a median ADI score of 18 out of 100, with half having a score between 8 and 28. Subjects who lived in high disadvantaged neighborhoods had a median age of 44 years, and were 66.5% female, 73.3% White, and 11.4% Hispanic, with 46.0% having completed a Bachelor's or Advanced degree. Cigarette exposure was higher, with 5.8% being current smokers and 13.0% being exposed to smoke at home, as well as having a high-risk health condition (37.0%).

ADI was associated with COVID-19 vaccination in multivariate models COVID (OR = 0.79, 95% CI: 0.65 – 0.95) (**Table 6**), indicating that subjects who lived in higher disadvantaged neighborhoods had lower odds of being fully vaccinated compared with subjects living in lower disadvantaged neighborhoods. Several patient factors were associated with higher odds of being vaccinated: Older age (65+ years OR = 2.39, 95% CI: 1.77 – 3.23, compared with 25-44 years old); race (Asian race OR = 1.75, 95% CI: 1.20 – 2.57; Other race OR = 2.25, 95% CI: 1.30 – 3.91, compared to White race); and having an advanced degree (OR = 1.31, 95% CI: 1.02 – 1.68,

compared to having a Bachelor's degree). Being male (OR = 0.76, 95% CI: 0.63 – 0.93, compared to female subjects), cigarette use (OR 0.53, 95% CI: 0.30 – 0.92) and household exposure to smoke (OR = 0.64, 95% CI: 0.44 – 0.93) were associated with reduced odds of vaccine uptake. Education was also associated with lower odds: Subjects who had completed high school and those with a high school degree were almost half as likely to be vaccinated (OR = 0.51, 95% CI: 0.49, 0.77) and those with some college had 0.71 lower odds (95% CI: 0.56, 0.89).

ADI was not associated with COVID-19 positivity in multivariable models (OR = 0.89, 95% CI: 0.71 – 1.10) (**Table 7**). Cigarette use was the only patient factor associated with decreased odds of test positivity (OR = 0.15; 95% CI: 0.07, 0.34), compared to those who did not smoke at all. Male subjects (OR = 1.28, 95% CI: 1.04, 1.59, compared to female subjects) and household exposure to smoke (OR = 1.62; 95% CI: 1.90 – 2.42, compared to unexposed subjects) were associated with increased odds of COVID-19 positivity.

Discussion

ADI has most recently been used to research disparities in COVID-19 mortality and to allocate vaccines in an equitable manner.[23,24] Our study findings only determined that ADI was associated with COVID-19 vaccine uptake but not influenza vaccination, influenza positivity or COVID-19 positivity. Study findings suggest that ADI might have been relevant in communication in key communities surrounding COVID-19 vaccine roll-out that did not exist with influenza vaccination policy. Further, test positivity remained similar across ADI, suggesting it is not a factor associated with increased positivity for influenza or COVID-19. Overall, ADI is not a necessary confounder in the analysis of vaccine effectiveness for influenza and COVID-19, in populations with a low median ADI.

Though study findings do not fully align with other studies that have found strong statistically significant associations between ADI with influenza and COVID outcomes, it is important to note that COVID-19 vaccine uptake was a significant association. In December 2020, the Food and Drug Administration approved the first COVID-19 vaccine for Emergency Use Authorization, and it became imperative to vaccinate as many people as possible to minimize further transmission and curb morality rates.[25] Several recommendations were used to guide state and local county health departments on how to appropriately allocate and distribute vaccines. The National Academies of Science, Engineering, and Medicine (NASEM) developed a framework

that recommended high-risk healthcare workers and first responders, people with comorbidities and adults over 75 living in crowded settings be prioritized for vaccination. ACIP had similar recommendations and outlined that healthcare workers and long-term care facilities' residents, essential workers, and adults over 65 or those with high-risk medical conditions should be prioritized in the first phase.[25] Transparency, maximization of benefits, minimization of harms and health inequities, and promotion of justice guided the development of these recommendations and frameworks. Washington state adopted these frameworks through a phased approach that also prioritized individuals living in congregated settings, an expanded first responder definition, and individuals living in multi-generational households.[26] After COVID-19 vaccines were available for all populations, Washington Department of Health (DOH) established a Care-a-Van program, a mobile health clinic that worked with community partners and local health jurisdictions to increase access to vaccine for priority communities.[27] DOH used a similar measure as the ADI score, the social vulnerability index, to prioritize the use of mobile clinics in communities that ranked high on experiencing external stressors on health and groups with lower vaccination rates, among other factors.[27] Similar to other healthcare systems, KPWA distributed COVID-19 vaccines to identified communities in phased approach as described above.

Given the careful planning around vaccine prioritization to avoid health disparities, it is astounding that differences based on neighborhood deprivation persisted in this study population, given access to health insurance, vaccinations, and medical care. It is also essential to note where Washington ranks nationally based on ADI scores. According to the Neighborhood Atlas, Washington state has a median ADI score of 28.[21] Our study population had a median ADI score of 19, which is 9 points lower than Washington state average, and most subjects in this study had an ADI score of 35 or less. The US Flu VE Network was recruiting in 6 other US regions between 2018 - 2022. In those regions, excluding California, the median ADI scores ranged from 61 to 68.[ii] Compared to other states, Washington and the study subjects rank low on disadvantage. These rankings further highlight the lasting association between ADI score and COVID-19 vaccine uptake and indicates the profound impact an individual's neighborhood may have in receiving public health interventions. Considering the lack of association between higher levels of

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[ii] The FluVE network consists of five study sites across the United States in 2018 – 2021 and expanded to seven in 2021 - 2022. Participating sites during this timeframe are listed below (State, Median ADI score): Kaiser Permanente of Southern California (Southern California, 15); University of Michigan (Michigan, 68); University of Pittsburgh (Pennsylvania, 61); Baylor Scott & White Health (Texas, 62); Vanderbilt University (Tennessee, 66); Kaiser Permanente Washington (Washington, 28); Marshfield Clinic Research Institute (not applicable).

disadvantage and the uptake of influenza vaccine, this finding highlights the heightened influence of the ADI specifically during public health emergencies. Further studies should evaluate whether more heterogenous ADI is more significantly associated with influenza vaccine uptake or with viral test positivity.

Associations between ADI and other COVID-19 outcomes were found in other studies. In Louisiana, researchers used cumulative positive COVID cases to assess the association with neighborhood deprivation. The study demonstrated an increased risk of infection between the least deprived neighborhoods and most deprived, after adjusting for urbanicity.[7] Another study assessing this association was conducted in Harris County, Texas. Researchers analyzed relationships between overall ADI scores, neighborhood characteristics and community incidence of COVID. ADI was significantly associated with higher incidence rates, as well as a higher percentage of Black populations, foreign-born populations, percentages of households with no vehicles and populations older than 65 years.[3] Lastly, a study assessing the association between prevalence of COVID-19 among seven states and ADI, found two states had a significant and positive correlation after adjusting for age, gender and geographical neighborhood size. Lack of association in the remaining five states was attributed to lower testing rates.[8] However, these studies have used primarily used publicly available data and have focused on adjusting on neighborhood level factors, rather than controlling for individual demographics. The granular, individual-level data is a study strength and future analyses with other FluVE sites could be conducted to incorporate a wider range of ADI scores. Additionally, due to prior studies' reliance on aggregated county data, these studies have only been able to assess associations at specific points in time, rather than collect data through multiple years.

As with other studies, our study results also found race and ethnicity, sex and age were associated with positive lab results and vaccine uptake.[2,6,23,28] However, due to the low percentages of non-White subjects and lack of non-English speaking patients, it may have been challenging to evaluate disparities in COVID outcomes among minoritized populations and non- or limited English speakers as has been observed in other studies.[2,29]

One surprising finding was the association between cigarette use and testing positive for COVID-19 after adjusting for sociodemographic and health-related factors. Though smoking is a risk factor for respiratory infectious diseases and severe COVID outcomes, prior studies found current cigarette use was associated with significantly lower odds of COVID infection. The causal

pathways between smoking and COVID infection are unclear but there are several behavioral hypotheses.[30,31] It may be that smokers understood their increased risk and tested for COVID upon having any symptoms.[30] However, this idea is refuted by the negative association with vaccine uptake, indicting a lack of engagement in health promoting behavior. It is more likely that smokers meet the criteria for testing as they may present with more ARI symptoms, such as coughing and shortness of breath because of smoking.[32] This would lead to more smokers being tested who may not have an ARI, thus potentially inflating the rate of smokers testing negative.[31]

In general, social determinants of health are valuable to identify people who need additional support or increased access to resources. The Department of Health and Human Services ended the federal COVID-19 public health emergency (PHE) on May 11, 2023, signaling an end to free testing and vaccines. Though the PHE designation reduced or eliminated costs associated with testing and vaccines, studies still found negative associations between insurance status and COVID cases. Uninsured populations have been found to have lower odds of vaccine uptake, highlighting the need for expanded access to healthcare to improve testing and preventative care.[33] This study controlled for insurance as the population was restricted to individuals who are enrolled with and have insurance through KPWA, limiting our ability to understand the impact insurance may have on ADI and clinical outcomes.

Our study had several important strengths. Key covariates and outcomes were ascertained through standardized methods, including enrollment survey, EHR and laboratory confirmed results. Other strengths included having a defined population of those seeking medical care for ARI and within 9 days of disease onset; a validated exposure measure; and combined decades of experience by a high-quality research team. Nonetheless the study has some limitations. The study population represents those who are sick and chose to participate in the study. Historically, participation rates for all FluVE subjects have varied between 2018 to 2022. Prior to 2020, rates among eligible subjects were between 94 – 96%. From 2020 – 2021, the rate dropped to less than 60% among those who were screened and eligible but rebounded the following season to about 76%. Secondly, the study population is also not generalizable to the general population, given that everyone is required to be a KPWA member and primarily seeks care at urban medical centers. Third, results may be different with the inclusion of subjects under 18 years old. Lastly, the ADI score is not fully representative of neighborhoods as the Census has limited information accounting

for all populations, such as undocumented, immigrant communities or highly population communities such as incarcerated individuals.

In general, findings suggest that ADI is not a confounder for analysis of influenza and COVID positivity, and influenza vaccine uptake. This likely indicates that prior influenza vaccine effectiveness estimates are likely not misrepresented to ACIP. However, this study revealed that neighborhood deprivation is still important for emergent vaccine rollouts. As new vaccines and interventions are developed and distributed, future public health emergency and ACIP policies should include explicit considerations to prioritize resources and focus to disadvantaged areas.

Figure 1: Kaiser Permanente Washington Data Sources and Collection Methods, 2018 – 2022

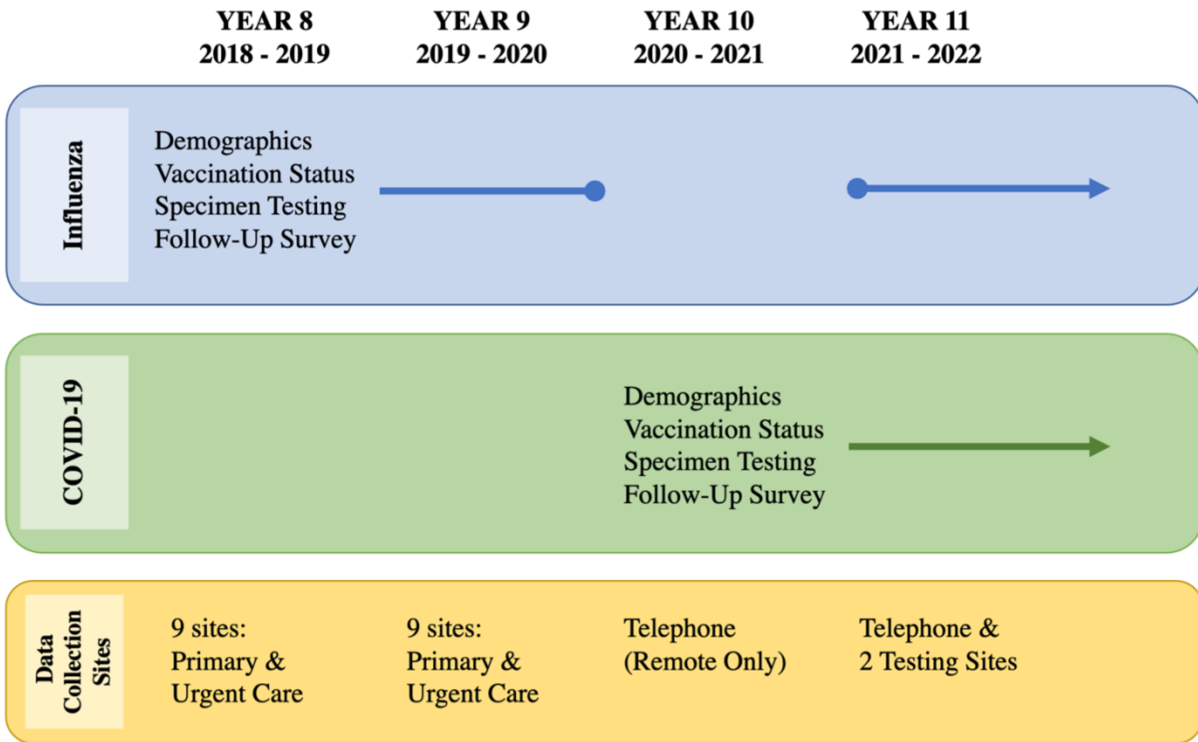

Figure 2: CONSORT Flow Diagram

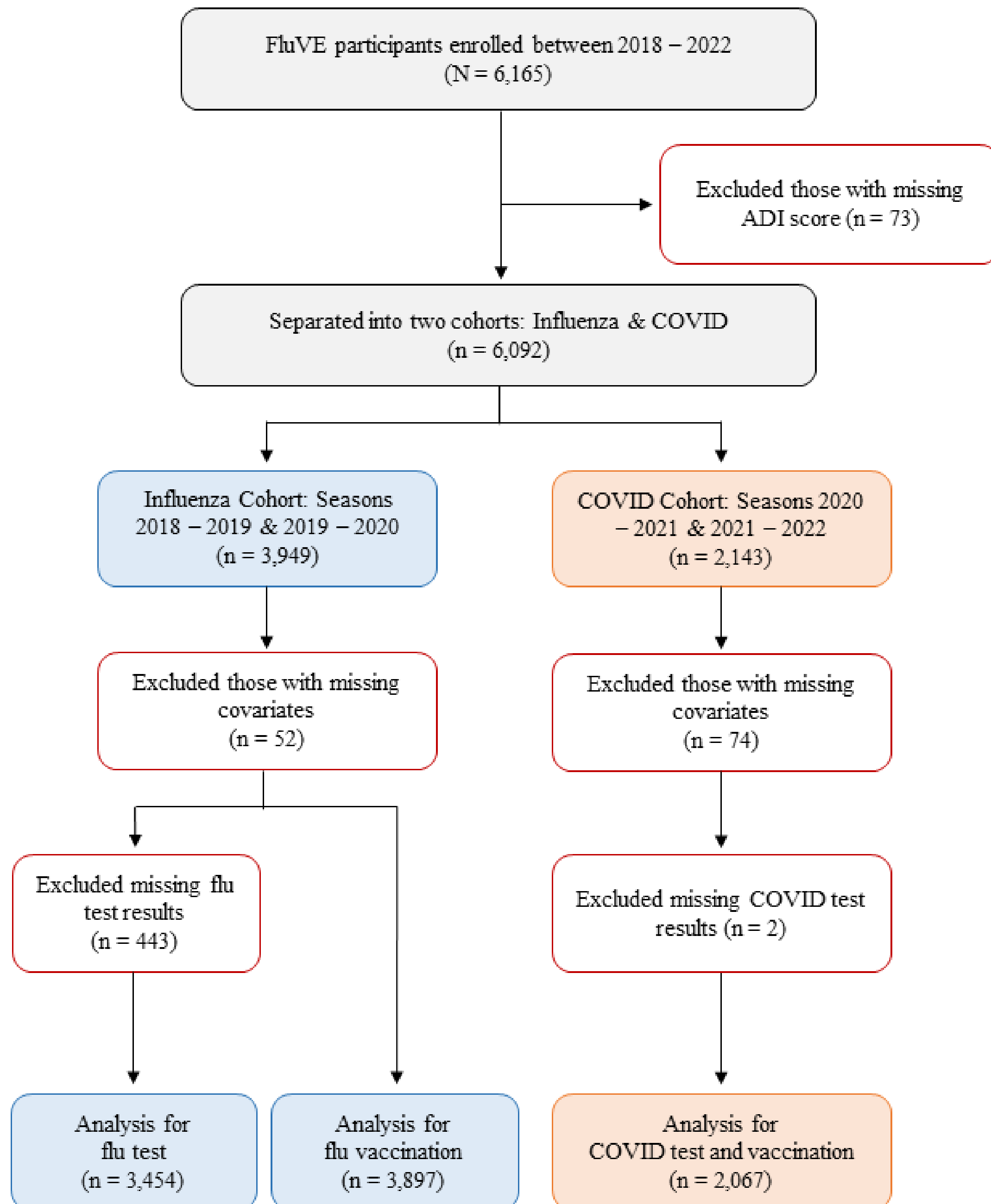

Table 1: Sociodemographic Characteristics of Enrolled Patients Over 18 Years of Age by Area Deprivation Index Categorization, 2018 – 2022 (N = 6,092)

	AREA DEPRIVATION INDEX[1]		**OVERALL**
	Low Disadvantage (n = 3,081)	High Disadvantage (n = 3,011)	
ENROLLMENT			
2018 - 2019	948 (30.8)	1091 (36.2)	2039 (33.5)
2019 - 2020	954 (31.0)	956 (31.8)	1910 (31.4)
2020 - 2021	709 (23.0)	673 (22.4)	1382 (22.7)
2021 - 2022	470 (15.3)	291 (9.7)	761 (12.5)
SEX			
Female	1901 (61.7)	2003 (66.5)	3904 (64.1)
Male	1180 (38.3)	1008 (33.5)	2188 (35.9)
AGE (Median, IQR)	49 (33, 64)	46 (33, 59)	47 (33, 61)
Age 18 - 24	215 (7.0)	240 (8.0)	455 (7.5)
Age 25 - 44	1154 (37.5)	1186 (39.4)	2340 (38.4)
Age 45 - 64	973 (31.6)	1115 (37.0)	2088 (34.3)
Age 65 and Older	739 (24.0)	470 (15.6)	1209 (19.8)
RACE			
American Indian or Alaska Native	25 (0.8)	42 (1.4)	67 (1.1)
Asian	299 (9.8)	192 (6.4)	491 (8.1)
Black or African American	107 (3.5)	199 (6.7)	306 (5.1)
Native Hawaiian or Pacific Islander	28 (0.9)	49 (1.6)	77 (1.3)
White or Caucasian	2298 (75.1)	2195 (73.7)	4493 (74.4)
Other	128 (4.2)	107 (3.6)	235 (3.9)
More than 1 Race	175 (5.7)	195 (6.5)	370 (6.1)
ETHNICITY			
Non-Hispanic	2816 (91.7)	2689 (89.7)	5505 (90.7)
Hispanic	255 (8.3)	310 (10.3)	565 (9.3)
EDUCATION			
< High School Graduate, High School Graduate or GED	260 (8.4)	498 (16.6)	758 (12.5)
Some College	904 (29.4)	1288 (42.8)	2192 (36.0)
Bachelor's Degree	984 (32.0)	730 (24.3)	1714 (28.2)
Advanced Degree	931 (30.2)	491 (16.3)	1422 (23.4)
CIGARETTE EXPOSURE			
No Cigarette Use	2890 (93.8)	2694 (89.5)	5584 (91.7)
Cigarette Use	190 (6.2)	316 (10.5)	506 (8.3)
No Household Exposure	2708 (88.7)	2421 (81.2)	5129 (85.0)
Household Exposure	345 (11.3)	561 (18.8)	906 (15.0)
HEALTH CONDITIONS			
No High-Risk Conditions	1913 (62.1)	1816 (60.3)	3729 (61.2)
1 or More High-Risk Conditions[2]	1168 (37.9)	1195 (39.7)	2363 (38.8)
ADI (Median, IQR)	9 (5, 14)	31 (25, 40)	19 (9, 31)

Data are presented as number and percentage (n, %) unless otherwise indicated.

1. Area Deprivation Index (ADI) national rankings range from 1 (lowest level of disadvantage) to 100 (highest level of disadvantage). ADI categories are based on the study population's median ADI score, 19. Low disadvantage is 1 – 19, high disadvantage is 20 – 100.
2. Medical history of a high-risk health condition including heart or lung disease, diabetes, malignant cancer and/ or liver failure.

Table 2: Sociodemographic Characteristics of Influenza Cohort by Area Deprivation Index Categorization, 2018 – 2020 (N = 3,897)

	AREA DEPRIVATION INDEX[1]		**OVERALL**
	Low Disadvantage (n = 1,876)	High Disadvantage (n = 2,021)	
ENROLLMENT			
2018 - 2019	930 (49.6)	1073 (53.1)	2003 (51.4)
2019 - 2020	946 (50.4)	948 (46.9)	1894 (48.6)
SEX			
Female	1171 (62.4)	1341 (66.4)	2512 (64.5)
Male	705 (37.6)	680 (33.6)	1385 (35.5)
AGE (Median, IQR)	50 (34, 66)	47 (33, 60)	49 (33, 63)
Age 18 - 24	135 (7.2)	174 (8.6)	309 (7.9)
Age 25 - 44	640 (34.1)	745 (36.9)	1385 (35.5)
Age 45 - 64	593 (31.6)	778 (38.5)	1371 (35.2)
Age 65 and Older	508 (27.1)	324 (16.0)	832 (21.3)
RACE			
American Indian or Alaska Native	19 (1.0)	28 (1.4)	47 (1.2)
Asian	198 (10.6)	137 (6.8)	335 (8.6)
Black or African American	61 (3.3)	126 (6.2)	187 (4.8)
Native Hawaiian or Pacific Islander	22 (1.2)	37 (1.8)	59 (1.5)
White or Caucasian	1414 (75.4)	1501 (74.3)	2915 (74.8)
Other	81 (4.3)	68 (3.4)	149 (3.8)
More than 1 Race	81 (4.3)	124 (6.1)	205 (5.3)
ETHNICITY			
Non-Hispanic	1738 (92.6)	1835 (90.8)	3573 (91.7)
Hispanic	138 (7.4)	186 (9.2)	324 (8.3)
EDUCATION			
< High School Graduate, High School Graduate or GED	182 (9.7)	372 (18.4)	554 (14.2)
Some College	566 (30.2)	876 (43.3)	1442 (37.0)
Bachelor's Degree	559 (29.8)	457 (22.6)	1016 (26.1)
Advanced Degree	569 (30.3)	316 (15.6)	885 (22.7)
CIGARETTE EXPOSURE			
No Cigarette Use	1764 (94.0)	1789 (88.5)	3553 (91.2)
Cigarette Use	112 (6.0)	232 (11.5)	344 (8.8)
No Household Exposure	1647 (87.8)	1588 (78.6)	3235 (83.0)
Household Exposure	229 (12.2)	433 (21.4)	662 (17.0)
HEALTH CONDITIONS			
No High-Risk Conditions	1121 (59.8)	1198 (59.3)	2319 (59.5)
1 or More High-Risk Conditions[2]	755 (40.2)	823 (40.7)	1578 (40.5)
ADI (Median, IQR)	9 (5, 13)	32 (26, 41)	20 (10, 33)

Data are presented as number and percentage (n, %) unless otherwise indicated.

1. Area Deprivation Index (ADI) national rankings range from 1 (lowest level of disadvantage) to 100 (highest level of disadvantage). ADI categories are based on the study population's median ADI score, 19. Low disadvantage is 1 – 19, high disadvantage is 20 – 100.
2. Medical history of a high-risk health condition including heart or lung disease, diabetes, malignant cancer and/ or liver failure.

Table 3: Sociodemographic Characteristics of COVID-19 Cohort by Area Deprivation Index Categorization, 2020 – 2022 (N = 2,067)

	AREA DEPRIVATION INDEX[1]		OVERALL
	Low Disadvantage (n = 1,147)	High Disadvantage (n = 920)	
ENROLLMENT			
2020 - 2021	703 (61.3)	660 (71.7)	1363 (65.9)
2021 - 2022	444 (38.7)	260 (28.3)	704 (34.1)
SEX			
Female	700 (61.0)	612 (66.5)	1312 (63.5)
Male	447 (39.0)	308 (33.5)	755 (36.5)
AGE (Median, IQR)	45 (32, 61)	44 (33, 58)	44 (32, 60)
Age 18 - 24	78 (6.8)	62 (6.7)	140 (6.8)
Age 25 - 44	488 (42.5)	413 (44.9)	901 (43.6)
Age 45 - 64	357 (31.1)	308 (33.5)	665 (32.2)
Age 65 and Older	224 (19.5)	137 (14.9)	361 (17.5)
RACE			
American Indian or Alaska Native	6 (0.5)	14 (1.5)	20 (1.0)
Asian	96 (8.4)	51 (5.5)	147 (7.1)
Black or African American	42 (3.7)	68 (7.4)	110 (5.3)
Native Hawaiian or Pacific Islander	5 (0.4)	10 (1.1)	15 (0.7)
White or Caucasian	859 (74.9)	674 (73.3)	1533 (74.2)
Other	47 (4.1)	38 (4.1)	85 (4.1)
More than 1 Race	92 (8.0)	65 (7.1)	157 (7.6)
ETHNICITY			
Non-Hispanic	1041 (90.8)	815 (88.6)	1856 (89.8)
Hispanic	106 (9.2)	105 (11.4)	211 (10.2)
EDUCATION			
< High School Graduate, High School Graduate or GED	69 (6.0)	115 (12.5)	184 (8.9)
Some College	314 (27.4)	381 (41.4)	695 (33.6)
Bachelor's Degree	411 (35.8)	258 (28.0)	669 (32.4)
Advanced Degree	353 (30.8)	166 (18.0)	519 (25.1)
CIGARETTE EXPOSURE			
No Cigarette Use	1092 (95.2)	867 (94.2)	1959 (94.8)
Cigarette Use	55 (4.8)	53 (5.8)	108 (5.2)
No Household Exposure	1034 (90.1)	800 (87.0)	1834 (88.7)
Household Exposure	113 (9.9)	120 (13.0)	233 (11.3)
HEALTH CONDITIONS			
No High-Risk Conditions	753 (65.6)	580 (63.0)	1333 (64.5)
1 or More High-Risk Conditions[2]	394 (34.4)	340 (37.0)	734 (35.5)
ADI (Median, IQR)	9 (5, 14)	30 (24, 38)	18 (8, 28)

Data are presented as number and percentage (n, %) unless otherwise indicated.

1. Area Deprivation Index (ADI) national rankings range from 1 (lowest level of disadvantage) to 100 (highest level of disadvantage). ADI categories are based on the study population's median ADI score, 19. Low disadvantage is 1 – 19, high disadvantage is 20 – 100.
2. Medical history of a high-risk health condition including heart or lung disease, diabetes, malignant cancer and/ or liver failure.

Table 4: Multivariate Logistic Regression Results of ADI Scores and Influenza Vaccination by Patient Characteristics, 2018 – 2020 (N = 3,897)

	INFLUENZA VACCINATION[1]		MULTIVATIATE ANALYSIS[2]		
	Unvaccinated (n = 1,773)	Vaccinated (n = 2,124)	OR	95% CI	p-value
ADI					
Low Disadvantage	805 (45.4)	1071 (50.4)	*1.00 (Reference)*		
High Disadvantage	968 (54.6)	1053 (49.6)	1.03	0.89, 1.18	0.726
SEX					
Female	1105 (62.3)	1407 (66.2)	*1.00 (Reference)*		
Male	668 (37.7)	717 (33.8)	0.78	0.68, 0.90	**0.001**
AGE					
Age 18 - 24	201 (11.3)	108 (5.1)	0.86	0.66, 1.12	0.261
Age 25 - 44	804 (45.3)	581 (27.4)	*1.00 (Reference)*		
Age 45 - 64	610 (34.4)	761 (35.8)	1.66	1.42, 1.95	**< 0.001**
Age 65 and Older	158 (8.9)	674 (31.7)	4.74	3.80, 5.91	**< 0.001**
RACE					
American Indian or Alaska Native	26 (1.5)	21 (1.0)	0.78	0.42, 1.44	0.426
Asian	133 (7.5)	202 (9.5)	1.39	1.09, 1.77	**0.009**
Black or African American	95 (5.4)	92 (4.3)	0.89	0.65, 1.21	0.447
Native Hawaiian or Pacific Islander	30 (1.7)	29 (1.4)	1.06	0.61, 1.83	0.833
White or Caucasian	1309 (73.8)	1606 (75.6)	*1.00 (Reference)*		
Other	77 (4.3)	72 (3.4)	1.13	0.76, 1.67	0.544
More than 1 Race	103 (5.8)	102 (4.8)	1.10	0.81, 1.49	0.532
ETHNICITY					
Non-Hispanic	1588 (89.6)	1985 (93.5)	*1.00 (Reference)*		
Hispanic	185 (10.4)	139 (6.5)	0.83	0.63, 1.08	0.166
EDUCATION					
< High School Graduate, High School Graduate or GED	303 (17.1)	251 (11.8)	0.61	0.49, 0.77	**< 0.001**
Some College	701 (39.5)	741 (34.9)	0.72	0.61, 0.86	**< 0.001**
Bachelor's Degree	440 (24.8)	576 (27.1)	*1.00 (Reference)*		
Advanced Degree	329 (18.6)	556 (26.2)	1.11	0.91, 1.35	0.310
CIGARETTE EXPOSURE					
No Cigarette Use	1572 (88.7)	1981 (93.3)	*1.00 (Reference)*		
Cigarette Use	201 (11.3)	143 (6.7)	0.75	0.54, 1.04	0.080
No Household Exposure	1419 (80.0)	1816 (85.5)	*1.00 (Reference)*		
Household Exposure	354 (20.0)	308 (14.5)	0.99	0.77, 1.27	0.924
HEALTH CONDITIONS					
No High-Risk Conditions	1261 (71.1)	1058 (49.8)	*1.00 (Reference)*		
1 or More High-Risk Conditions	512 (28.9)	1066 (50.2)	1.72	1.48, 1.99	**< 0.001**

Table 5: Multivariate Logistic Regression Results of ADI Scores and Influenza Test Outcomes by Patient Characteristics, 2018 – 2020 (N = 3,454)

	INFLUENZA TEST RESULT		MULTIVATIATE ANALYSIS[2]		
	Negative (n = 2,601)	Positive (n = 853)	OR	95% CI	p-value
ADI[1]					
Low Disadvantage	1259 (48.4)	374 (43.8)	*1.00 (Reference)*		
High Disadvantage	1342 (51.6)	479 (56.2)	1.16	0.99, 1.37	0.071
SEX					
Female	1692 (65.1)	530 (62.1)	*1.00 (Reference)*		
Male	909 (34.9)	323 (37.9)	1.16	0.99, 1.37	0.069
AGE					
Age 18 - 24	200 (7.7)	72 (8.4)	0.92	0.67, 1.25	0.579
Age 25 - 44	855 (32.9)	344 (40.3)	*1.00 (Reference)*		
Age 45 - 64	912 (35.1)	301 (35.3)	0.88	0.73, 1.06	0.175
Age 65 and Older	634 (24.4)	136 (15.9)	0.64	0.50, 0.82	**< 0.001**
RACE					
American Indian or Alaska Native	27 (1.0)	13 (1.5)	1.46	0.74, 2.88	0.277
Asian	227 (8.7)	88 (10.3)	1.26	0.96, 1.64	0.091
Black or African American	123 (4.7)	45 (5.3)	1.15	0.81, 1.64	0.443
Native Hawaiian or Pacific Islander	30 (1.2)	27 (3.2)	2.84	1.66, 4.85	**< 0.001**
White or Caucasian	1963 (75.5)	596 (69.9)	*1.00 (Reference)*		
Other	98 (3.8)	38 (4.5)	1.08	0.70, 1.66	0.731
More than 1 Race	133 (5.1)	46 (5.4)	1.05	0.74, 1.49	0.795
ETHNICITY					
Non-Hispanic	2396 (92.1)	769 (90.2)	*1.00 (Reference)*		
Hispanic	205 (7.9)	84 (9.8)	1.13	0.84, 1.53	0.425
EDUCATION					
< High School Graduate, High School Graduate or GED	383 (14.7)	138 (16.2)	1.01	0.78, 1.31	0.942
Some College	973 (37.4)	308 (36.1)	0.95	0.77, 1.16	0.603
Bachelor's Degree	659 (25.3)	222 (26.0)	*1.00 (Reference)*		
Advanced Degree	586 (22.5)	185 (21.7)	1.01	0.80, 1.26	0.956
CIGARETTE EXPOSURE					
No Cigarette Use	2377 (91.4)	766 (89.8)	*1.00 (Reference)*		
Cigarette Use	224 (8.6)	87 (10.2)	1.21	0.83, 1.76	0.319
No Household Exposure	2155 (82.9)	698 (81.8)	*1.00 (Reference)*		
Household Exposure	446 (17.1)	155 (18.2)	0.90	0.67, 1.20	0.461
HEALTH CONDITIONS					
No High-Risk Conditions	1471 (56.6)	557 (65.3)	*1.00 (Reference)*		
1 or More High-Risk Conditions	1130 (43.4)	296 (34.7)	0.79	0.66, 0.94	**0.008**

Table 6: Multivariate Logistic Regression Results of ADI Scores and COVID-19 Vaccination by Patient Characteristics, 2020 – 2022 (N = 2,067)

	COVID-19 VACCINATION[1]		**MULTIVATIATE ANALYSIS**[2]		
	Unvaccinated (n = 847)	Vaccinated (n = 1,220)	OR	95% CI	p-value
ADI					
Low Disadvantage	422 (49.8)	725 (59.4)	*1.00 (Reference)*		
High Disadvantage	425 (50.2)	495 (40.6)	0.79	0.65, 0.95	**0.013**
SEX					
Female	512 (60.4)	800 (65.6)	*1.00 (Reference)*		
Male	335 (39.6)	420 (34.4)	0.76	0.63, 0.93	**0.006**
AGE					
Age 18 - 24	63 (7.4)	77 (6.3)	1.25	0.85, 1.82	0.256
Age 25 - 44	406 (47.9)	495 (40.6)	*1.00 (Reference)*		
Age 45 - 64	288 (34.0)	377 (30.9)	1.12	0.91, 1.39	0.285
Age 65 and Older	90 (10.6)	271 (22.2)	2.39	1.77, 3.23	**< 0.001**
RACE					
American Indian or Alaska Native	12 (1.4)	8 (0.7)	0.62	0.24, 1.60	0.322
Asian	45 (5.3)	102 (8.4)	1.75	1.20, 2.57	**0.004**
Black or African American	47 (5.5)	63 (5.2)	1.16	0.77, 1.76	0.470
Native Hawaiian or Pacific Islander	9 (1.1)	6 (0.5)	0.61	0.21, 1.84	0.383
White or Caucasian	635 (75.0)	898 (73.6)	*1.00 (Reference)*		
Other	24 (2.8)	61 (5.0)	2.25	1.30, 3.91	**0.004**
More than 1 Race	75 (8.9)	82 (6.7)	0.85	0.60, 1.20	0.346
ETHNICITY					
Non-Hispanic	760 (89.7)	1096 (89.8)	*1.00 (Reference)*		
Hispanic	87 (10.3)	124 (10.2)	1.10	0.78, 1.55	0.590
EDUCATION					
< High School Graduate, High School Graduate or GED	105 (12.4)	79 (6.5)	0.51	0.36, 0.72	**< 0.001**
Some College	336 (39.7)	359 (29.4)	0.71	0.56, 0.89	**0.003**
Bachelor's Degree	252 (29.8)	417 (34.2)	*1.00 (Reference)*		
Advanced Degree	154 (18.2)	365 (29.9)	1.31	1.02, 1.68	**0.038**
CIGARETTE EXPOSURE					
No Cigarette Use	772 (91.1)	1187 (97.3)	*1.00 (Reference)*		
Cigarette Use	75 (8.9)	33 (2.7)	0.53	0.30, 0.92	**0.025**
No Household Exposure	707 (83.5)	1127 (92.4)	*1.00 (Reference)*		
Household Exposure	140 (16.5)	93 (7.6)	0.64	0.44, 0.93	**0.020**
HEALTH CONDITIONS					
No High-Risk Conditions	575 (67.9)	758 (62.1)	*1.00 (Reference)*		
1 or More High-Risk Conditions	272 (32.1)	462 (37.9)	1.08	0.88, 1.32	0.482

Table 7: Multivariate Logistic Regression Results of ADI Scores and COVID-19 Test Results by Patient Characteristics, 2018 – 2020 (N = 2,067)

	COVID-19 TEST RESULT		**MULTIVATIATE ANALYSIS**[2]		
	Negative (n = 1,593)	Positive (n = 474)	OR	95% CI	p-value
ADI					
Low Disadvantage	876 (55.0)	271 (57.2)	*1.00 (Reference)*		
High Disadvantage	717 (45.0)	203 (42.8)	0.89	0.71, 1.10	0.270
SEX					
Female	1032 (64.8)	280 (59.1)	*1.00 (Reference)*		
Male	561 (35.2)	194 (40.9)	1.28	1.04, 1.59	**0.023**
AGE					
Age 18 - 24	114 (7.2)	26 (5.5)	0.70	0.44, 1.12	0.141
Age 25 - 44	696 (43.7)	205 (43.2)	*1.00 (Reference)*		
Age 45 - 64	497 (31.2)	168 (35.4)	1.14	0.90, 1.46	0.280
Age 65 and Older	286 (18.0)	75 (15.8)	0.90	0.65, 1.25	0.519
RACE					
American Indian or Alaska Native	13 (0.8)	7 (1.5)	2.16	0.81, 5.73	0.123
Asian	104 (6.5)	43 (9.1)	1.40	0.96, 2.06	0.084
Black or African American	87 (5.5)	23 (4.9)	0.99	0.61, 1.61	0.977
Native Hawaiian or Pacific Islander	11 (0.7)	4 (0.8)	1.33	0.41, 4.26	0.634
White or Caucasian	1189 (74.6)	344 (72.6)	*1.00 (Reference)*		
Other	64 (4.0)	21 (4.4)	1.34	0.75, 2.41	0.327
More than 1 Race	125 (7.8)	32 (6.8)	0.91	0.60, 1.37	0.647
ETHNICITY					
Non-Hispanic	1424 (89.4)	432 (91.1)	*1.00 (Reference)*		
Hispanic	169 (10.6)	42 (8.9)	0.73	0.48, 1.11	0.139
EDUCATION					
< High School Graduate, High School Graduate or GED	144 (9.0)	40 (8.4)	0.95	0.63, 1.44	0.810
Some College	526 (33.0)	169 (35.7)	1.11	0.86, 1.44	0.433
Bachelor's Degree	509 (32.0)	160 (33.8)	*1.00 (Reference)*		
Advanced Degree	414 (26.0)	105 (22.2)	0.79	0.59, 1.05	0.098
CIGARETTE EXPOSURE					
No Cigarette Use	1493 (93.7)	466 (98.3)	*1.00 (Reference)*		
Cigarette Use	100 (6.3)	8 (1.7)	0.15	0.07, 0.34	**< 0.001**
No Household Exposure	1409 (88.4)	425 (89.7)	*1.00 (Reference)*		
Household Exposure	184 (11.6)	49 (10.3)	1.62	1.09, 2.42	**0.017**
HEALTH CONDITIONS					
No High-Risk Conditions	1024 (64.3)	309 (65.2)	*1.00 (Reference)*		
1 or More High-Risk Conditions	569 (35.7)	165 (34.8)	0.948	0.75, 1.20	0.655

Table 8: Uni- and Multivariate Logistic Regression Results of Influenza and COVID Outcomes by Binary ADI Categories (Low vs. High Disadvantage), 2018 – 2022[1]

COHORT		UNADJUSTED			ADJUSTED		
		OR[2]	*95% CI*[2]	*p-value*	*OR*[2]	*95% CI*[2]	*p-value*
Influenza	*Vaccination Uptake*	0.818	0.721, 0.928	**0.002**	1.025	0.891, 1.180	0.726
(2018 – 2020)	*Positive Test Result*	1.202	1.028, 1.404	**0.021**	1.164	0.987, 1.371	0.071
COVID	*Vaccination Uptake*	0.678	0.568, 0.809	**< 0.001**	0.787	0.652, 0.950	**0.013**
(2020 – 2022)	*Positive Test Result*	0.915	0.744, 1.126	0.401	0.885	0.713, 1.099	0.270

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