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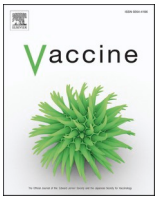

Vaccination uptake in LGBTQ adults in two US states: Findings from the QVax study

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ABSTRACT

Objectives: Lesbian, gay, bisexual, transgender, queer and other (LGBTQ+) individuals face numerous health disparities, including higher rates of chronic diseases and sexually transmitted infections, partly due to marginalization, discrimination, and a healthcare system often unprepared to meet their specific needs. Despite the importance of vaccination in preventing these health issues, vaccination patterns in LGBTQ+ populations remain under-researched, with limited data available due to the absence of sexual orientation and gender identity information on most healthcare forms. As such, we sought to understand vaccine uptake among LGBTQ+ individuals living in New Jersey and New York for 7 primary adult vaccines.

Methods: Participants were 768 LGBTQ+ adults living in New Jersey and New York, US. We recruited this convenience sample through community centers and events, social media, and listservs of local professional organizations. The online survey examined uptake for 7 adult vaccines.

Results: Of the 7 adult vaccines, human papilloma virus (HPV) had the lowest proportion of participants who were fully/partially vaccinated (54.4 %), followed by hepatitis A (59.8 %), hepatitis B (63.0 %), meningitis B (63.7 %), seasonal influenza during the COVID-19 pandemic (70.2 %), seasonal influenza before the COVID-19 pandemic (70.3 %), and nearly all participants (99.2 %) received at least one dose of the COVID-19 vaccine. For Shingles virus, among participants age 50+, 63.8 % were fully/partially vaccinated. In adjusted models, age was the strongest predictor of vaccination uptake in HPV, hepatitis A, hepatitis B, meningitis B, and seasonal influenza before and during the COVID-19 pandemic. Younger participants were more likely to be vaccinated for 4 of the 6 vaccines, excluding Shingles (<0.001), whereas older adults were more likely to be vaccinated for seasonal influenza before and during the COVID-19 pandemic (<0.010).

Conclusions: This study highlights the differences in uptake across different vaccines. It also draws attention to differences within LGBTQ+ populations which is important to consider when ensuring more equitable vaccine access.

1. Introduction

In the United States (US), LGBTQ+ (lesbian, gay, bisexual, transgender, and queer) individuals experience numerous health disparities [1] including higher rates of chronic diseases [2,3], and sexually transmitted infections [4], many of which can be prevented via vaccination. These health challenges stem from chronic marginalization and discrimination [5,6], some of which are state-sanctioned [7], and are compounded by a healthcare workforce that is often unprepared to address the specific needs of this population [8,9]. Other factors that contribute to inadequate care include general lack of provider knowledge on healthcare needs [10,11], previous stigmatizing experiences in healthcare settings [12,13], and discomfort around discussing sexual orientation [14–16] or gender identity and expression [17]. Overall vaccination patterns in LGBTQ+ populations have not been widely documented due in part to the lack of sexual orientation and gender

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identity (SOGI) data on most healthcare intake forms [18]. The few studies that do exist primarily focus on human papilloma virus (HPV) [19] with more recent research focusing on COVID-19 [20–22]. For example, college students who identify as LGBTQ+ are more likely to report COVID-19 vaccine uptake compared to their heterosexual peers [22].

Few studies have examined vaccine uptake within the different subgroups of LGBTQ+ populations as most have focused on comparisons to non-LGBTQ+ populations. For example, one study found that bisexual women had higher adjusted odds of HPV vaccination initiation and completion compared to heterosexual women, while no differences were observed between lesbian and heterosexual women [23]. The same study also found that gay men had higher adjusted odds of initiating and completing HPV vaccination compared to heterosexual men, with no differences observed between bisexual and heterosexual men [23]. For older gay, bisexual, and other men who have sex with men (MSM), economic barriers along with guideline and evidentiary gaps have created challenges for HPV vaccine uptake compared to their younger counterparts [19].

Recent work examining differences of COVID-19 vaccination uptake found that gay and lesbian participants reported higher vaccination coverage than their heterosexual counterparts [20]. However, it is important to note that the intersection of race/ethnicity and sexual orientation/gender identity revealed disparities in vaccine uptake within LGBTQ+ populations [20]. More specifically, the data highlighted racial and ethnic disparities, with Black lesbian women having some of the lowest vaccination rates, while white gay men had some of the highest rates [20]. Other studies have demonstrated that in general, LGBTQ+ people are accepting of the COVID-19 vaccine [24,25], however acceptability for other vaccines including HPV [26,27] and hepatitis B [28], has been varied by sexual orientation and gender identity. Moreover, prior investigations of vaccine attitudes among LGBTQ+ populations have also identified prevalent altruistic and prosocial attitudes, which are positively associated with vaccine acceptability and uptake [24,25,29].

While this previous work is extremely important, LGBTQ+ populations are not monolithic, and it is important to understand whether there are more nuanced differences in vaccine uptake within LGBTQ+ sub-groups. Furthermore, due to the climate around overall vaccine hesitancy amidst COVID-19 and recognizing pre-existing health disparities and medical mistrust that is prevalent within LGBTQ+ populations that puts members at increased vulnerability to myriad vaccine preventable diseases (VPD), we sought to assess vaccinate uptake and adherence within this population. The primary objective of this study is to examine vaccination more broadly and to delineate the sociodemographic characteristics of vaccination in key VPD among LGBTQ+ people living in New Jersey (NJ) and New York (NY). We hypothesize rates of vaccination for COVID-19 are high for our sample due to the altruistic attitudes of community safety and protection during the pandemic [30]. We also hypothesize that lower rates of vaccine uptake exist across our other vaccinations of interest including HPV, hepatitis A, hepatitis B, meningitis B, RZV, seasonal influenza (prior to and during the COVID-19 pandemic). Finally, as noted we expect to see disparities by key demographics including race/ethnicity and age in alignment with previous studies that have examined these differences [19,20].

2. Materials and methods

2.1. Participants

We conducted a cross-sectional internet-based survey, known locally as QVax, from October 2021—November 2022 to examine vaccine uptake, access, and hesitancy for key vaccinations among LGBTQ+ adults living in NJ and NY. Participants were eligible if they were 18 years or older, identified as LGBTQ+, and lived in NJ or NY. Study protocol and activities were approved by the Rutgers University Institutional Review Board.

This convenience sample of participants provided self-reported data on demographics. Age was re-coded into four categories (18–29, 30–39, 40–49, and $\geq$ 50). Participants reported their: sex assigned at birth (male/female), gender identity (cisgender man, cisgender woman, transgender man, transgender woman, non-binary/genderqueer/gender non-conforming, or a free-text option), and sexual orientation (gay, lesbian, bisexual, asexual, queer, heterosexual or straight, or a free-text option). For race and ethnicity, participants were asked to choose all the that apply: Hispanic/Latino, American Indian/Alaska Native, Black/African American, Asian, Middle Eastern or North African, Native Hawaiian or Pacific Islander, White, or "other"; responses were used to constitute the analytic groups: Hispanic/Latino, Black non-Hispanic, Asian/Native Hawaiian or Pacific Islander non-Hispanic, American Indian/Alaska Native/ Middle Eastern or North African/other non-Hispanic, multiracial non-Hispanic, and White non-Hispanic.

For a nuanced understanding of the intersectionality of SOGI we categorized participants into 15 groups for each combination of SOGI. Due to small cell sizes, we combined transgender people into 2 subgroups for each sexual orientation category. The combined SOGI analytic groups are gay cisgender men, bisexual/other sexual orientation (SO) cisgender men, lesbian cisgender women, bisexual/other SO cisgender women, transgender men (all SO), transgender women (all SO), non-binary people (all SO).

We also gathered data on employment (unemployed, employed full-time/part-time), nation of birth (United States, outside United States), and state of residence (NJ, NY). Additionally, participants self-reported their HIV status (positive, negative, unknown).

2.2. Procedures

The survey was hosted on Qualtrics XM [31]. Participants were recruited from NJ and NY-based LGBTQ+ community centers (i.e., African American Office of Gay Concerns, Garden State Equality, etc.) and events (i.e., New York City Pride, New Jersey Pride, etc.), social media (Facebook, Instagram, Twitter, etc.), and listservs of local professional organizations (i.e., New Jersey Pride Chamber of Commerce, public health affiliate chapters in NY and NJ, etc.) with an anonymous link to the survey. After answering screening questions to determine eligibility, those who were eligible provided informed consent and were then directed to the survey which took approximately 15–20 min to complete. Upon completion, all participants had an opportunity to enter a raffle to win one of fifteen $30 electronic gift cards.

Our team used comprehensive data cleaning procedures based on past experiences with bots and "bad actors" [32]. Records were removed if they met any of the following criteria: received a Google reCAPTCHA [33] score below 0.5, submitted duplicate answers for qualitative questions, completed less than 75 % of the entire survey, or did not provide a zip code. We also removed records where the zip code and county of residence did not align; however, special considerations were made if the zip code was alphabetically (e.g., Hudson and Hunterdon) or geographically (e.g., Erie and Niagara) adjacent and cross-checked by two team members to ensure data integrity. Our final sample size included $n = 768$ participants.

2.3. Measures

2.3.1. Vaccination Uptake

The survey asked participants to report their history of vaccination for HPV, hepatitis A, hepatitis B, meningitis B, RZV (shingles), seasonal influenza (prior to and during the COVID-19 pandemic), and COVID-19. Within our survey, we used the most known name and acronym for each vaccine to ensure clarity for participants. We also included a brief description about each vaccine (e.g., 'Hepatitis A is given to children and is recommended for people who are men who have sex with men and/or inject drugs. Hepatitis A can cause severe liver infection.') in an effort to

help participants distinguish their vaccination history. Additionally, for each vaccine, participants were asked if they had received all recommended doses (yes, no, I received at least one dose but not both/all, and I can't recall). For analytic purposes, those who selected "I can't recall" were categorized as missing and those who had received all and some recommended doses were classified as fully/partially vaccinated with all others classified as not vaccinated.

2.4. Statistical analysis

This analysis examined the self-reported history of vaccination for HPV, hepatitis A, hepatitis B, meningitis B, shingles (RZV), seasonal influenza before and during the COVID-19 pandemic), and COVID-19 by key sociodemographic characteristics. Descriptive statistics were computed for all sociodemographic characteristics and vaccination variables. We then analyzed the relationship between vaccination uptake and sociodemographic characteristics. After conducting bivariable analyses using nonparametric χ^2 tests of independence with critical value set at $p = 0.05$, we used binary logistic regression models to calculate crude odds (OR) and adjusted odds ratios (AOR) for vaccine uptake. Adjusted models controlled for age, gender identity, sexual orientation, and race/ethnicity. For multivariable models, sexual orientation and gender identity were entered separately to allow for a more nuanced analysis. Unadjusted and adjusted odds ratios were conducted using statistically significant variables from chi-square testing ($p < 0.05$; Table 2). All models were adjusted for age, race, sexual orientation, and gender identity, additional variables were added based on statistical significance in the unadjusted model. The high uptake of vaccination for COVID-19 among the sample resulted in instances of perfect prediction in regression models and was therefore omitted from some analyses. Additionally, we did not assess RZV in the final models as there were no statistically significant associations at the bivariate level. To account for multiple simultaneous comparisons, a Bonferroni correction was applied. Table 2 reports *p*-values using the unadjusted alpha and denote when significance was not achieved after corrected alpha was applied. All analyses were conducted with SPSS V28.

2.5. Our Positionality

We write as a collective of five public health researchers, comprising two recent Master of Public Health (MPH) graduates, two early career- and one senior-level PhD holders who have all collectively been engaged in LGBTQ+ research for nearly five decades. Many of the authors identify as members of the LGBTQ+ community and the rest are close allies who are deeply dedicated to this work. All of us were engaged in public health training and research during the onset of the COVID-19 pandemic and were actively involved in different studies examining the immediate impact of the COVID-19 pandemic on LGBTQ+ populations and people living with HIV. While we differ in our research epistemology and methods, we share a fundamental commitment to diversity, equity, and social justice within our research portfolios.

3. Results

3.1. Sociodemographic Characteristics.

The mean age of all participants was 34.2 (SD:13.3; Range:18–90) and the majority were White non-Hispanic (68.2 %) (Table 1). Using the more nuanced SOGI classification that combines sexual orientation and gender identity, one-quarter of respondents (25.0 %) identified as gay cisgender men, 12.8 % identified as lesbian cisgender women, 12.9 % identified as bisexual cisgender women, and 10.8 % identified as another sexual orientation and as nonbinary individuals. Further, 83.1 % of participants were employed either part-time or full-time. Fifty participants (6.5 %) self-reported an HIV-positive status. The vast majority (91.3 %) were US-born and live in NJ (73.0 %).

Table 1
Descriptive statistics for QVax participants living in NJ and NY ($n = 768$).

Demographic	% (n)
Age, mean (SD)	34.23 / 13.25
Age, y	
18–29	46.0 (353)
30–39	30.5 (234)
40–49	8.5 (65)
≥ 50	15.1 (116)
Race/Ethnicity	
American Indian, non-Hispanic	0.8 (6)
Asian non-Hispanic	5.6 (43)
Black non-Hispanic	7.6 (58)
Hispanic/Latino	11.7 (90)
Middle Eastern non-Hispanic	0.4 (3)
Native Hawaiian non-Hispanic	0.5 (4)
White non-Hispanic	68.2 (524)
Other non-Hispanic	0.5 (4)
Mixed Race	4.7 (36)
Sexual Orientation and Gender Identity	
Gay Cisgender Men	25.0 (192)
Bisexual Cisgender Men	2.9 (22)
Other Sexual Orientation Cisgender Men	1.0 (8)
Lesbian Cisgender Women	12.8 (98)
Bisexual Cisgender Women	12.9 (99)
Other Sexual Orientation Cisgender Women	8.1 (62)
Gay Transgender Men	3.5 (27)
Bisexual Transgender Men	2.3 (18)
Other Sexual Orientation Transgender Men	2.9 (22)
Lesbian Transgender Women	3.5 (27)
Bisexual Transgender Women	1.6 (12)
Other Sexual Orientation Transgender Women	0.7 (5)
Gay/Lesbian Nonbinary	6.8 (52)
Bisexual Nonbinary	5.3 (41)
Other Sexual Orientation Nonbinary	10.8 (83)
Employment Status	
Unemployed	16.5 (127)
Employed Full-Time	62.9 (483)
Employed Part-Time	20.2 (155)
HIV Status	
Positive/Undetectable	4.9 (38)
Positive/Detectable	1.6 (12)
Negative	85.3 (655)
Unknown	8.1 (62)
Nation of Birth	
Outside United States	7.4 (57)
United States	91.3 (701)
State Residence	
New Jersey	73.0 (561)
New York	27.0 (207)

3.2. Vaccination Uptake.

To better understand routine adult vaccinations, fully and partially vaccinated participants were considered one category (Fig. 1). Over half (54.4 %) of the sample had received at least one dose of HPV vaccine. Approximately 60 % of participants were vaccinated for hepatitis A, 63 % were vaccinated for hepatitis B, and 63.7 % had received a meningitis B vaccination. Seasonal influenza immunization rates prior to and during the COVID-19 pandemic remained consistent at 70.2 % and 70.3 %, respectively. Almost the entire sample of 768 participants were at least partially vaccinated for COVID-19 (96.6 %). Of those 50+ years of age, 63.8 % ($n = 74$) had received the recommended RZV vaccine.

3.3. Vaccination by Sociodemographic Characteristics.

Statistically significant associations were found between age and vaccination for HPV ($\chi^2 = 220.59$, df = 3, $p \leq 0.001$), hepatitis A ($\chi^2 = 58.01$, df = 3, $p \leq 0.001$), hepatitis B ($\chi^2 = 87.47$, df = 3, $p \leq 0.001$), meningitis B ($\chi^2 = 233.37$, df = 3, $p \leq 0.001$), seasonal influenza before the COVID-19 pandemic ($\chi^2 = 11.37$, df = 3, $p = 0.010$), and seasonal influenza during the COVID-19 pandemic ($\chi^2 = 11.37$, df = 3, $p = 0.003$).

Table 2
Binary logistic regression models examining vaccination uptake in a survey of LGBTQ+ people, by sociodemographic characteristics, NJ and NY, 2021–2022.

	Human Papilloma Virus (HPV) ***N* = 666**			**Hepatitis A** ***N* = 575**			**Hepatitis B** ***N* = 583**		
	OR (95 % CI) [*p*-value]	AOR (95 % CI) [*p*-value]	χ^2 [p-value]	OR (95 % CI) [*p*-value]	AOR (95 % CI) [*p*-value]	χ^2 [p-value]	OR (95 % CI) [*p*-value]	AOR (95 % CI) [*p*-value]	χ^2 [p-value]
Age Group			220.59 [**<0.001**]			58.01 [**<0.001**]			87.47 [**<0.001**]
18–29	1.0	1.0		1.0	1.0		1.0	1.0	
30–39	0.23 (0.146–0.352) [**<0.001**]	0.24 (0.15–0.39) [**<0.001**]		1.06 (0.597–1.1865) [0.854]	0.98 (0.52–1.84) [0.952]		2.43 (1.169–5.062) [**0.017**] [a]	2.39 (1.09–5.23) [**0.029**] [a]	
40–49	0.06 (0.030–0.116) [**<0.001**]	0.07 (0.03–0.13) [**<0.001**]		0.45 (0.206–0.963) [**0.040**] [a]	0.32 (0.14–0.74) [**0.009**]		0.66 (0.283–1.537) [0.335]	0.53 (0.21–1.36) [0.187]	
50+	0.02 (0.010–0.038) [**<0.001**]	0.03 (0.02–0.07) [**<0.001**]		0.18 (0.206–0.963) [**<0.001**]	0.10 (0.05–0.21) [**<0.001**]		0.16 (0.091–0.267) [**<0.001**]	0.09 (0.04–0.10) [**<0.001**]	
Race/Ethnicity			21.66 [**<0.001**]			9.98 [0.076]			5.92 [0.314]
White non-Hispanic	1.0	1.0		1.0	1.0		1.0	1.0	
American Indian /MEA / Other, non-Hispanic	1.85 (0.571–5.982) [0.305]	0.80 (0.15–4.27) [0.790]		0.42 (0.133–1.310) [0.134]	0.30 (0.06–1.38) [0.121]		0.80 (0.216–2.928) [0.731]	0.59 (0.11–3.31) [0.548]	
Asian, non-Hispanic / NH	5.92 (2.058–17.006) [**<0.001**]	2.95 (1.01–8.66) [**0.048**] [a]		3.78 (0.883–16.184) [0.073]	1.29 (0.33–4.96) [0.707]		2.31 (0.689–7.775) [0.175]	0.74 (0.22–2.49) [0.625]	
Black non-Hispanic	2.33 (1.216–4.472) [**0.011**]	2.04 (0.92–4.52) [0.079]		0.61 (0.319–1.140) [0.119]	0.49 (0.23–1.01) [0.054]		0.69 (0.341–1.383) [0.293]	0.45 (0.20–1.02) [0.057]	
Hispanic/ Latino	1.57 (0.935–2.642) [0.088]	1.13 (0.60–2.14) [0.704]		2.27 (1.000–5.161) [**0.050**]	1.55 (0.62–3.85) [0.349]		2.13 (0.886–5.140) [0.091]	1.65 (0.59–4.61) [0.343]	
Multiracial, non-Hispanic	1.70 (0.791–3.656) [0.174]	1.26 (0.48–3.28) [0.642]		0.78 (0.321–1.906) [0.589]	0.59 (0.22–1.58) [0.290]		0.94 (0.373–2.371) [0.896]	0.73 (0.25–2.13) [0.561]	
Gender Identity			68.92 [**<0.001**]			13.14 [**0.022**]			19.81 [**0.001**]
Cisgender Man	1.0	1.0		1.0	1.0		1.0	1.0	
Cisgender Woman	3.60 (2.390–5.410) [**<0.001**]	1.81 (1.05–3.14) [**0.034**] [a]		1.03 (0.619–1.724) [0.900]	0.38 (0.19–0.76) [**0.006**]		1.33 (0.742–2.385) [0.338]	0.43 (0.20–0.93) [**0.032**] [a]	
Transgender Man	5.89 (2.931–11.842) [**<0.001**]	2.69 (1.18–6.14) [**0.019**] [a]		0.90 (0.440–1.838) [0.771]	0.29 (0.12–0.70) [**0.006**]		0.60 (0.287–1.253) [0.174]	0.15 (0.06–0.40) [**<0.001**]	
Transgender Woman	3.35 (1.553–7.217) [**0.002**]	1.76 (0.71–4.37) [0.225]		0.59 (0.255–1.339) [0.204]	0.27 (0.10–0.76) [**0.013**] [a]		0.50 (0.218–1.145) [0.101]	0.17 (0.06–0.51) [**<0.001**]	
Nonbinary	4.47 (2.704–7.378) [**<0.001**]	1.55 (0.78–3.08) [0.209]		2.47 (1.175–5.200) [**0.017**] [a]	0.80 (0.32–1.96) [0.619]		1.71 (0.820–3.561) [0.152]	0.46 (0.17–1.19) [0.109]	
Other Identity	0.95 (0.422–2.151) [0.908]	0.90 (0.32–2.50) [0.836]		0.50 (0.207–1.214) [0.126]	0.33 (0.11–0.98) [**0.045**] [a]		0.33 (0.141–0.761) [**0.009**] [a]	0.16 (0.05–0.50) [**0.002**]	
Sexual Orientation			39.99 [**<0.001**]			8.15 [**0.017**]			14.17 [**<0.001**]
Gay/Lesbian	1.0	1.0		1.0	1.0		1.0	1.0	
Bisexual	2.68 (1.799–4.003) [**<0.001**]	1.44 (0.87–2.41) [0.156]		1.60 (0.958–2.659) [0.072]	1.21 (0.66–2.24) [0.538]		2.37 (1.304–4.315) [**0.005**]	1.47 (0.72–2.99) [0.290]	
Other	2.99 (1.966–4.555) [**<0.001**]	1.61 (0.92–2.80) [0.094]		2.10 (1.184–3.727) [**0.011**]	1.66 (0.83–3.30) [0.149]		2.46 (1.330–4.545) [**0.004**]	1.84 (0.88–3.85) [0.106]	
Employment Status			2.99 [0.084]			2.62 [0.105]			2.97 [0.085]
Employed	–	–		–	–		–	–	
Unemployed	–	–		–	–		–	–	
HIV Status			5.58 [0.061]			3.71 [0.157]			4.53 [0.104]
HIV Negative	–	–		–	–		–	–	
HIV Positive	–	–		–	–		–	–	
HIV Status Unknown	–	–		–	–		–	–	
Born in the U.S.			0.43 [0.512]			5.22 [**0.022**]			4.25 [**0.039**]

(*continued on next page*)

Table 2 (*continued*)

	Human Papilloma Virus (HPV) ***N* = 666**			**Hepatitis A** ***N* = 575**			**Hepatitis B** ***N* = 583**		
	OR (95 % CI) [*p*-value]	AOR (95 % CI) [*p*-value]	χ^2 [p-value]	OR (95 % CI) [*p*-value]	AOR (95 % CI) [*p*-value]	χ^2 [p-value]	OR (95 % CI) [*p*-value]	AOR (95 % CI) [*p*-value]	χ^2 [p-value]
Yes	–	–		1.0	1.0		1.0	1.0	
No	–	–		0.27 (0.08–0.90) [**0.032**] [a]	3.75 (1.07–13.17) [**0.039**] [a]		0.31 (0.09–1.01) [**0.051**] [a]	3.55 (0.99–12.70) [**0.051**] [a]	
State of Residence			3.13 [0.077]			0.45 [0.500]			4.08 **[0.043]**
New Jersey	–	–		–	–		1.0	1.0	
New York	–	–		–	–		0.58 (0.34–0.99) [**0.045**] [a]	1.79 (0.97–3.32) [0.063]	

a. non-significant at Bonferroni corrected p-value

	Meningitis B ***N* = 604**			**COVID-19** ***N* = 762**		
	OR (95 % CI) [*p*-value]	AOR (95 % CI) [*p*-value]	χ^2 [p-value]	OR (95 % CI) [*p*-value]	AOR (95 % CI) [*p*-value]	χ^2 [p-value]
Age Group			233.37 [**<0.001**]			1.97 [0.578]
18–29	1.0	1.0		1.0	–	
30–39	0.51 (0.257–0.990) [**0.047**] [a]	0.45 (0.22–0.94) [**0.033**] [a]		2.05 (0.652–6.427) [0.220]	–	
40–49	0.12 (0.054–0.261) [**<0.001**]	0.11 (0.05–0.25) [**<0.001**]		2.28 (0.291–17.834) [0.433]	–	
50+	0.02 (0.008–0.034) [**<0.001**]	0.01 (0.01–0.03) [**<0.001**]		1.32 (0.365–4.754) [0.674]	–	
Race/Ethnicity			8.14 [0.314]			
White non-Hispanic	1.0	1.0		–	–	
American Indian/MEA/ Other, non-Hispanic	1.56 (0.339–7.151) [0.569]	1.60 (0.10–26.08) [0.741]		–	–	
Asian, non-Hispanic/NH	3.02 (0.904–10.087) [0.073]	1.42 (0.36–5.53) [0.617]		–	–	
Black non-Hispanic	1.42 (0.639–3.132) [0.392]	0.65 (0.24–1.71) [0.377]		–	–	
Hispanic/Latino	2.16 (0.996–4.676) [0.051]	1.40 (0.52–3.83) [0.507]		–	–	
Multiracial, non-Hispanic	1.91 (0.651–5.602) [0.238]	2.14 (0.62–8.86) [0.295]		–	–	
Gender Identity			36.63 [**<0.001**]			18.54 **[0.002]**
Cisgender Man	1.0	1.0		1.0	–	
Cisgender Woman	2.94 (1.742–4.954) [**<0.001**]	0.88 (0.41–1.91) [0.747]		2.78 (0.711–10.892) [0.142]	–	
Transgender Man	3.45 (1.386–8.577) [**0.008**]	0.91 (0.29–2.87) [0.878]		0.69 (0.173–2.747) [0.599]	–	
Transgender Woman	4.45 (1.301–15.247) [**0.017**]	1.41 (0.31–6.47) [0.657]		0.26 (0.077–0.849) [0.026]	–	
Nonbinary	2.43 (1.318–4.494) [**0.004**]	0.42 (0.16–1.07) [0.069]		4.60 (0.560–37.802) [0.156]	–	
Other Identity	0.50 (0.217–1.164) [0.108]	0.28 (0.08–0.93) [**0.038**]		1.09 (0.129–9.100) [0.940]	–	
Sexual Orientation			20.35 [**<0.001**]			1.28 [0.528]
Gay/Lesbian	1.0	1.0		1.0	–	
Bisexual	2.77 (1.595–4.820) [**<0.001**]	1.19 (0.57–2.49) [0.644]		1.80 (0.496–6.528) [0.371]	–	
Other	2.54 (1.440–4.482) [**<0.001**]	1.54 (0.72–3.30) [0.264]		0.82 (0.298–2.249) [0.698]	–	
Employment Status			6.63 **[0.010]**			0.157 [0.69]
Employed	1.0	1.0		–	–	
Unemployed	1.87 (1.16–3.03) [**0.011**]	1.05 (0.34–3.28) [0.931]		–	–	
HIV Status			3.35 [0.187]			13.95 [**<0.001**]
HIV Negative	–	–		1.0	–	

(*continued on next page*)

Table 2 (*continued*)

	Meningitis B ***N* = 604**			**COVID-19** ***N* = 762**		
	OR (95 % CI) [*p*-value]	AOR (95 % CI) [*p*-value]	χ^2 [p-value]	OR (95 % CI) [*p*-value]	AOR (95 % CI) [*p*-value]	χ^2 [p-value]
HIV Positive	–	–		5.69 (2.06–15.73) [**<0.001**]	–	
HIV Status Unknown	–	–		2.57 (0.50–13.34) [0.261]	–	
Born in the U.S.			0.00 [0.969]			1.51 [0.219]
Yes	–	–		–	–	
No	–	–		–	–	
State of Residence			0.85 [0.356]			0.10 [0.752]
New Jersey	–	–		–	–	
New York	–	–		–	–	

a. non-significant at Bonferroni corrected p-value

ˆ Due to the small sample size, there was perfect separation of variables and therefore results were inconclusive.

	Seasonal influenza before COVID-19 Pandemic ***N* = 737**			**Seasonal influenza during COVID-19 pandemic** ***N* = 740**		
	OR (95 % CI) [*p*-value]	AOR (95 % CI) [*p*-value]	χ^2 [p-value]	OR (95 % CI) [*p*-value]	AOR (95 % CI) [*p*-value]	χ^2 [p-value]
Age Group			11.37 **[0.010]**			13.65 **[0.003]**
18–29	1.0	1.0		1.0	1.0	
30–39	1.50 (1.028–2.201) [**0.035**] [a]	1.47 (0.98–2.19) [0.060]		1.63 (1.112–2.388) [**0.012**]	1.58 (1.06–2.37) [**0.026**] [a]	
40–49	1.46 (0.792–2.679) [0.227]	1.37 (0.73–2.58) [0.325]		1.67 (0.901–3.111) [0.103]	1.50 (0.79–2.86) [0.214]	
50+	2.30 (1.335–3.971) [**0.003**]	1.88 (1.02–3.45) [**0.042**] [a]		2.31 (1.355–3.940) [**0.002**]	1.78 (0.98–3.25) [0.059]	
Race/Ethnicity			13.53 **[0.019]**			11.84 **[0.037]**
White non-Hispanic	1.0	1.0		1.0	1.0	
American Indian /MEA/ Other, non-Hispanic	0.42 (0.148–1.168) [0.096]	0.21 (0.06–0.75) [**0.017**] [a]		0.28 (0.101–0.755) [**0.012**]	0.25 (0.07–0.86) [**0.028**] [a]	
Asian, non-Hispanic / NH	1.29 (0.602–2.779) [0.510]	1.67 (0.77–3.64) [0.197]		2.55 (0.982–6.643) [0.055]	2.34 (1.00–5.50) [0.051]	
Black non-Hispanic	1.18 (0.612–2.256) [0.628]	1.19 (0.61–2.34) [0.615]		1.06 (0.563–2.011) [0.848]	0.98 (0.50–1.91) [0.954]	
Hispanic/ Latino	0.73 (0.440–1.201) [0.214]	0.82 (0.48–1.39) [0.457]		0.70 (0.424–1.144) [0.153]	0.77 (0.46–1.31) [0.336]	
Multiracial, non-Hispanic	2.18 (0.830–5.738) [0.114]	2.53 (0.95–6.75) [0.064]		0.71 (0.34–1.458) [0.350]	0.83 (0.39–1.75) [0.621]	
Gender Identity			13.68 **[0.018]**			9.65 [0.089]
Cisgender Man	1.0	1.0		1.0	1.0	
Cisgender Woman	0.53 (0.347–0.810) [**0.003**]	0.60 (0.37–0.97) [0.039]		0.58 (0.382–0.889) [**0.012**]	0.83 (0.50–1.37) [0.470]	
Transgender Man	0.64 (0.337–1.215) [0.173]	0.71 (0.36–1.42) [0.332]		0.60 (0.320–1.108) [0.102]	0.90 (0.45–1.78) [0.760]	
Transgender Woman	1.15 (0.496–2.645) [0.750]	1.30 (0.54–3.12) [0.557]		1.18 (0.514–2.727) [0.692]	1.82 (0.75–4.42) [0.187]	
Nonbinary	0.65 (0.395–1.063) [0.086]	0.73 (0.41–1.31) [0.285]		0.63 (0.384–1.017) [0.058]	0.93 (0.52–1.66) [0.800]	
Other Identity	1.70 (0.565–5.133) [0.345]	1.44 (0.47–4.45) [0.524]		0.97 (0.393–2.375) [0.941]	1.06 (0.41–2.71) [0.909]	
Sexual Orientation			6.98 **[0.030]**			18.25 [**<0.001**]
Gay/Lesbian	1.0	1.0		1.0	1.0	
Bisexual	0.60 (0.407–0.878) [0.009]	0.77 (0.50–1.18) [0.225]		0.44 (0.296–0.641) [<0.001]	0.53 (0.34–0.82) [0.004]	
Other	0.86 (0.564–1.299) [0.465]	1.10 (0.68–1.78) [0.676]		0.72 (0.478–1.089) [0.120]	0.92 (0.57–1.47) [0.713]	
Employment Status			0.17 [0.674]			0.015 [0.904]
Employed	–	–		–	–	
Unemployed	–	–		–	–	
HIV Status			2.70 [0.259]			7.99 **[0.018]**
HIV Negative	–	–		1.0	1.0	

(*continued on next page*)

Table 2 (*continued*)

	Seasonal influenza before COVID-19 Pandemic ***N* = 737**			Seasonal influenza during COVID-19 pandemic ***N* = 740**		
	OR (95 % CI) [*p*-value]	AOR (95 % CI) [*p*-value]	χ^2 [p-value]	OR (95 % CI) [*p*-value]	AOR (95 % CI) [*p*-value]	χ^2 [p-value]
HIV Positive	–	–		1.74 (0.99–3.06) [0.054]	1.89 (0.78–4.59) [0.161]	
HIV Status Unknown	–	–		3.79 (1.45–9.94) [**0.007**]	0.58 (0.32–1.07) [0.080]	
Born in the U.S.			0.54 [0.461]			0.40 [0.527]
Yes	–	–		–	–	
No	–	–		–	–	
State of Residence			4.21 **[0.040]**			2.25 [0.137]
New Jersey	1.0	1.0		–	–	
New York	0.67 (0.45–0.98) [**0.041**] [a]	1.43 (0.96–2.13) [0.083]		–	–	

a. non-significant at Bonferroni corrected p-value

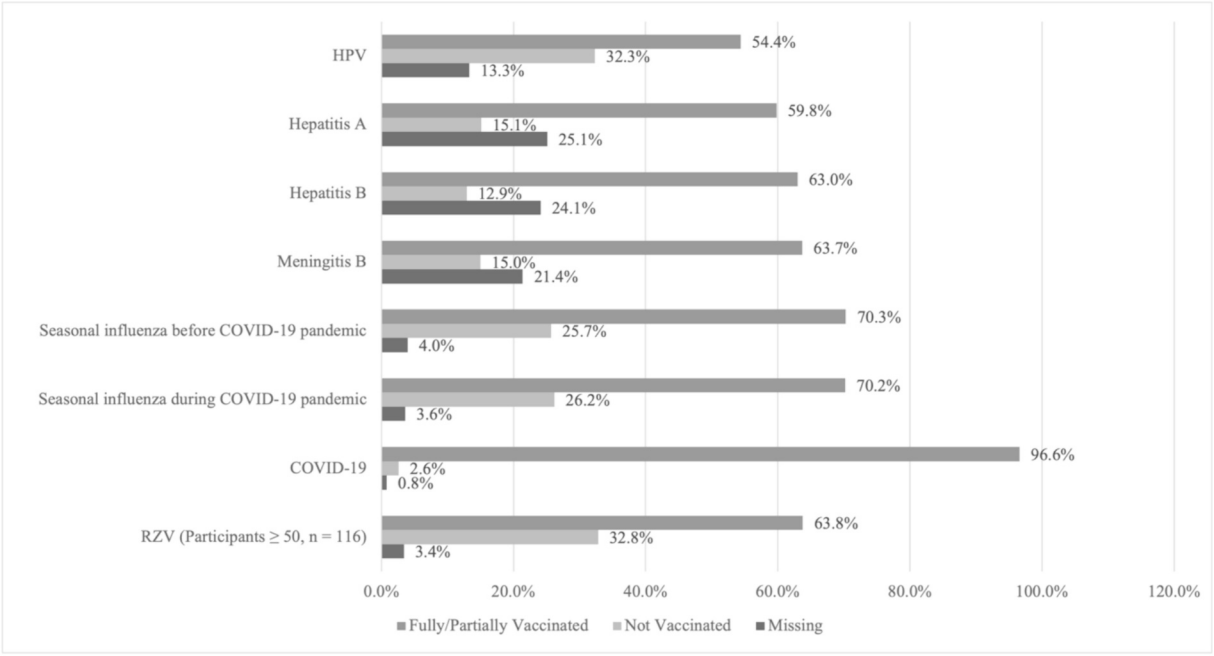

Fig. 1. Vaccine uptake for QVax participants living in NJ and NY (n = 768).
For the vaccine uptake variables, our missing categories include those who did not answer the question and those who endorsed 'unsure.'

Statistically significant associations were found between race/ethnicity and vaccination for HPV ($\chi^2 = 21.66$, df = 5, $p \leq 0.001$), seasonal influenza before the COVID-19 pandemic ($\chi^2 = 13.53$, df = 5, $p = 0.019$), and seasonal influenza during the COVID-19 pandemic ($\chi^2 = 11.84$, df = 5, $p = 0.037$).

Statistically significant associations were found between gender identity and vaccination for HPV ($\chi^2 = 68.92$, df = 5, $p \leq 0.001$), hepatitis A ($\chi^2 = 13.14$, df = 5, $p = 0.022$), hepatitis B ($\chi^2 = 19.81$, df = 5, $p = 0.001$), meningitis B ($\chi^2 = 36.63$, df = 5, $p \leq 0.001$), COVID-19 ($\chi^2 = 18.54$, df = 5, $p = 0.002$), seasonal influenza before the COVID-19 pandemic ($\chi^2 = 13.53$, df = 5, $p = 0.019$), and seasonal influenza during the COVID-19 pandemic ($\chi^2 = 11.84$, df = 5, $p = 0.037$).

Statistically significant associations were found between sexual orientation and vaccination for HPV ($\chi^2 = 39.99$, df = 2, $p \leq 0.001$), hepatitis A ($\chi^2 = 8.15$, df = 2, $p = 0.017$), hepatitis B ($\chi^2 = 14.17$, df = 2, $p \leq 0.001$), meningitis B ($\chi^2 = 20.35$, df = 2, $p \leq 0.001$), and seasonal influenza before the COVID-19 pandemic ($\chi^2 = 6.98$, df = 2, $p = 0.018$).

For employment, HIV status, born in the US, and state of residence, statistically significant associations were found between employment and vaccination for meningitis B ($\chi^2 = 6.63$, df = 1, $p = 0.010$). Statistically significant associations were found between HIV status and vaccination for COVID-19 ($\chi^2 = 13.95$, df = 2, $p \leq 0.001$) and seasonal influenza during the COVID-19 pandemic ($\chi^2 = 7.99$, df = 2, $p = 0.018$). Statistically significant associations were found between those born in the US and those not and vaccination for hepatitis A ($\chi^2 = 5.22$, df = 1, $p = 0.022$), and hepatitis B ($\chi^2 = 4.29$, df = 1, $p = 0.039$). Statistically significant associations were found between those living in NY vs NJ and vaccination for hepatitis B ($\chi^2 = 4.08$, df = 1, $p = 0.043$) and seasonal influenza before the COVID-19 pandemic ($\chi^2 = 4.21$, df = 1, $p = 0.040$).

3.4. Multivariate Models

The strongest predictor of HPV vaccination was age, with participants who were 30–39 having approximately 76 % lower odds ($p < 0.001$) and those aged 40–49 and 50+ years old having over 90 % lower odds ($p < 0.001$) of being vaccinated compared to those who were

18–29 years old. In adjusted models, cisgender women were 80 % more likely ($p = 0.034$) to be vaccinated compared to their cisgender male counterparts. Additionally, transgender men had 2.69 times the odds of being vaccinated for HPV ($p = 0.019$).

Age, gender identity, and nation of origin were strong predictors for both hepatitis A and hepatitis B vaccinations. Those who were aged 40–49, and 50+ had lower odds of being vaccinated for hepatitis A (OR = 0.32, $p = 0.009$; OR = 0.10, $p < 0.001$, respectively) compared to the 18–29 age group. Compared to cisgender men, all other gender identities had lower odds of being vaccinated for hepatitis A except nonbinary individuals ($p < 0.05$). People who were not born in the US had higher odds of being vaccinated for hepatitis A (OR = 3.75, $p = 0.039$. The final model for hepatitis B included state of residence. Compared to the 18–29 year olds, those who were ages 30–39 had the highest odds of being vaccinated (OR = 2.39, $p = 0.029$), and those aged 50+ had the lowest odds (OR = 0.09, $p < 0.001$). Cisgender women, transgender men, transgender women, and other gender identities all had over 50 % lower odds to be vaccinated for hepatitis A and B compared to cisgender men. Foreign-born participants had over 3.5 times the odds of being vaccinated for hepatitis A and hepatitis B than US-born individuals ($p = 0.039$ and $p = 0.051$, respectively).

Meningitis B vaccination uptake reflected a similar pattern to vaccination uptake of HPV, hepatitis A, and hepatitis B where age was a strong predictor. The final model included employment status in addition to other adjusted variables. Individuals who were 30–39 had 55 % lower odds of vaccination ($p < 0.033$) and those who were 40–49 were 89 % less likely ($p < 0.001$) to have received a meningitis B vaccination.

Results are analogous in the seasonal influenza vaccinations before and during the COVID-19 pandemic. The odds of 30–39-year olds of getting vaccinated during COVID-19 were OR = 1.58 ($p = 0.026$,) respectively, compared to 18–29-year olds. Furthermore, participants 50+ years were the most likely to receive the seasonal influenza vaccine prior to the COVID-19 pandemic (OR = 1.88, $p = 0.042$) and also during the COVID-19 pandemic (OR = 1.78, $p = 0.59$).

4. Discussion

This study contributes to the extremely limited knowledge available on vaccination uptake across among LGBTQ+ adults in New Jersey and New York. Of the 7 adult vaccines we surveyed, HPV had the lowest proportion of participants who were fully/partially vaccinated, followed by hepatitis A, hepatitis B, meningitis B, seasonal influenza during the COVID-19 pandemic, seasonal influenza before the COVID-19 pandemic, and nearly all participants received at least one dose of the COVID-19 vaccine. Our results also demonstrate that just over two-thirds of our participants over age 50 were at least partially vaccinated for RZV. We observed statistically significant variations in vaccination rates for most of the vaccinations across age groups, sexual orientations, and gender identities. Notably, younger individuals exhibited higher vaccination rates for HPV and meningitis B while older individuals were more likely to be vaccinated for seasonal influenza prior to and during the COVID-19 pandemic.

A deeper exploration into the within group differences reveal noteworthy disparities in vaccination uptake that are important in understanding the health behaviors within LGBTQ+ populations. Our study found that transgender men were more likely to be vaccinated for HPV compared to cisgender gay men, who had the lowest rate. Likewise, cisgender men who identified as bisexual or another sexual orientation had lower rates of COVID-19 and seasonal influenza vaccine uptake compared to other groups. These findings underscore the importance of considering the intersectionality of sexual orientation and gender identity within public health initiatives.

Our findings also reveal variations in vaccination uptake among participants, with the HPV vaccine having the lowest coverage at 54.4 %. This is followed by hepatitis A (59.8 %), hepatitis B (63.0 %), and meningitis B (63.7 %). Notably, influenza vaccination rates remained consistent both before and during the COVID-19 pandemic at approximately 70.3 % and 70.2 %, respectively. These variations underscore the need for targeted efforts to increase HPV vaccination rates, which are crucial given the vaccine's role in preventing certain cancers affecting many different groups within the LGBTQ+ population. The relatively lower rates of hepatitis A and B vaccinations also suggest gaps in protective measures against these infectious diseases, highlighting another noteworthy area for public health improvement.

Almost our entire sample (96.6 %) received at least one dose of the COVID-19 vaccine which made assessing differences between sociodemographic characteristics challenging, however it is a noteworthy finding in and of itself. Our previous work on the initial impact of the COVID-19 pandemic in LGBTQ communities showed that there were disparities in testing [34] and employment, [35] so the high inoculation rate for COVID-19 is reassuring. Similar findings were noted in a cross-sectional study examining COVID-19 vaccine intention among young adults in Canada and France in that LGBTQ individuals reported a higher level of vaccine acceptance compared to their heterosexual counterparts [36]. Additionally, in a study conducted among LGBTQ adults in New York City, 81 % of participants received at least one dose of the COVID-19 vaccine [21].

Our findings demonstrate that younger cohorts of LGBTQ+ people are most likely to be vaccinated for HPV compared to their older counterparts. Additionally, we also found that cisgender women and transgender men were statistically significantly more likely to be vaccinated for HPV compared to cisgender men. These results are not surprising given HPV vaccinations commenced in 2006, and while they were originally recommended for females and males ages 11–12, with catch-up vaccination recommended through age 26 [37], the vaccine's development and implementation trajectory had been focused on females due to its initial testing and subsequent marketing to prevent cervical cancer [38,39]. In the years to follow, it became available for all people through the age of 26 and was recommended for adults 27–45 in consultation with their healthcare providers [40]. In recent years, efforts have been made to expand HPV vaccine uptake among other LGBTQ+ communities, however more work needs to be done. In addition, Asian, non-Hispanic participants were more likely to be vaccinated compared to their White, non-Hispanic counterparts in our sample. Similar findings have been documented in the NIS-Teen 2012 study where Asian girls had slightly higher uptake and completion rates compared to White girls in the sample [41].

Age was also a statistically significant predictor for both hepatitis A and B vaccine uptake in that the youngest cohort was more likely to be vaccinated compared to the oldest. Similar to HPV, these results are not surprising given the recent update from the Centers for Disease Control and Prevention Advisory Committee on Immunization Practices expanding the age range to 18–59 for hepatitis B, in addition to the long-standing recommendation to vaccinate children under 18 [42]. The older study participants were statistically significantly less likely to be vaccinated for meningitis B. For years, many colleges and universities have mandated the meningitis B vaccine among students and the typical maximum age recommendation is 23 years old, [43] so our findings are not surprising given the age parameters of this particular vaccine. Recently, researchers examined the effectiveness of the meningitis B vaccine against gonorrhea infection in a cohort of gay, bisexual, and other MSM living with HIV [44]. The findings indicate that the vaccine was associated with lower risk of acquiring gonorrhea, which is an important breakthrough, especially in a community that is at high risk for the acquisition of sexually transmitted infections. While we did not observe any statistical differences in meningitis B vaccination among PLWH, updating the vaccination recommendations to include this population may help to confer protection against STIs including gonorrhea, and is in line with recommendations elsewhere in the world [44,45].

We also examined uptake of the seasonal influenza vaccine prior to and since the onset of the COVID-19 pandemic. Our findings indicate

that our older cohorts tend to be more vaccinated than their younger counterparts, which is contrary to the other vaccinations that we assessed. Given that many seasonal influenza campaigns and recommendations are targeted at older adults, our findings are in close alignment and consistent with the general population [46]. Moreover, adults ≥65 are the most vaccinated age cohort in NJ, the state where the largest proportion of our sample lives [47].

Taken together, our findings demonstrate the need for age-appropriate vaccination campaigns, especially as implementation guidelines change and the age range for many vaccinations expands to include older adults. Additionally, there remains a need to increase awareness of the importance of vaccination for sub-groups of the LGBTQ+ community that are at higher risk for certain VPD, such as transgender people and gay, bisexual, and other MSM for HPV-related cancers [48,49]. While we did not see statistically significant differences in our multivariate models by race/ethnicity for flu prior to or after the initial onset of the COVID-19 pandemic by race/ethnicity, we did see differences play out in our bivariate models. Black, Asian, and multiracial non-Hispanic participants were more likely to be vaccinated for seasonal influenza prior to the COVID-19 pandemic, and only Asian, non-Hispanic participants were more likely to be vaccinated for influenza after the initial onset of the COVID-19 pandemic, albeit not significantly based on statistical analyses. This is important to note though because the onset of the COVID-19 pandemic may have increased skepticism of other vaccinations among many racial/ethnic minorities.

During the COVID-19 pandemic, vaccine and medical mistrust increased across various populations due to mixed messages, rapid vaccine development, and politicization of public health measures [50]. Moreover, medical mistrust was already quite prevalent among LGBTQ+ populations prior to the onset of the COVID-19 pandemic, especially among those who are also racial and/or ethnic minorities [51–53]. Despite generally good COVID-19 vaccination uptake among LGBTQ+ individuals evidenced in our present study and other studies [21,36], it is important to consider that this already marginalized population may be more vulnerable to the ambient mistrust of other vaccines. The lasting impact of this mistrust, coupled with additional healthcare access barriers that arose during the pandemic—such as clinic closures and reduced services—should be continuously assessed in the LGBTQ+ population to ensure equitable healthcare access and outcomes. More research is needed on the impediments and facilitators to overall vaccination uptake within LGBTQ+ populations and more specifically on those with multiple marginalized identities.

4.1. Limitations

Our study has several limitations. First, the study used a convenience sample and thus is subjected to self-selection bias. Vaccination rates for VPD may be higher in our sample than the general population if people who are vaccinated are also more likely to complete the survey than those who are not. Additionally, the convenience sample may have led to an overrepresentation of some sociodemographic groups, which may hinder the generalizability of our findings. Second, all vaccination data were self-reported, which may present a recall bias about which vaccinations participants have or have not received, and whether they received the full dosing schedule. While there has been data to support self-reported vaccination status for COVID-19 [54], and seasonal influenza [55], research is inconsistent about many of the other vaccinations we examined including hepatitis A and B [56,57]. Similarly, we acknowledge that combining those who were partially vaccinated with those who were fully vaccinated may present a distorted picture, however, partial vaccination has been shown to be more efficacious across many vaccines than no vaccination [58,59]. Third, our data come from two states where vaccinations are relatively easy to obtain at public health facilities, pharmacies, and other medical offices. Moreover, our sample is not necessarily representative of the whole LGBTQ+ population in NY and NJ as many of our recruitment efforts were focused on areas where the community gathers and organizations many LGBTQ+ people often utilize for resources and support. As such, we likely missed those who may not be as engaged with LGBTQ+ events and organizations throughout each state. Fourth, most of our sample was white non-Hispanic and while we considered weighting responses, the lack of LGBTQ+ data at the population level inhibits assigning accurate weights. Fifth, we note that including some variables in multivariable analyses and not others can make it challenging to compare findings across vaccines and that selection of variables based on significance at the bivariable level may have arbitrarily led to exclusion of variables with plausible associations. We further note that due to the number of simultaneous comparisons, type-1 error rate maybe be inflated and thus we denote instances where associations failed to achieve significance using an adjusted alpha level. Finally, while we cleaned the data to the best of our ability, there remains a possibility of bot and 'bad actor' responses. Despite these limitations, having this breadth of data on vaccination uptake on common VPDs among LGBTQ+ people is critical for developing targeted vaccine campaigns and educational programs for community members and healthcare providers in the future.

5. Conclusions

This study highlights key sociodemographic correlates of vaccine uptake across many different VPD among a sample of LGBTQ+ adults. First, 96.6 % of our cohort was vaccinated for COVID-19. Next, our findings show that in general, except for seasonal influenza, older adults tend to be less vaccinated compared to their younger counterparts, despite many vaccines being available to older age groups. Additionally, we found that cisgender women and transgender men are statistically significantly more likely to be vaccinated for HPV even though gay, bisexual, and other MSM and transgender women are also at great risk for HPV-related cancers [48,49]. Moving forward, public health efforts to increase vaccine awareness must address the nuances of LGBTQ+ populations. Moreover, these efforts should consider the importance of capturing the multiple intersectional identities that LGBTQ+ people hold when developing vaccine messages and campaigns, as LGBTQ+ populations are not monolithic. Finally, more understanding is needed around facilitators and barriers to vaccine uptake within LGBTQ+ populations.

Ethical/Institutional Review Board Statement:

The study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the Institutional Review Board of Rutgers University (Pro2021001599, initially approved 9/21/2021). All participants provided informed consent.

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CRediT authorship contribution statement

Kristen D. Krause: Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Paul A. D'Avanzo:** Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **Anita G. Karr:** Writing – review & editing, Writing – original draft, Project administration, Investigation, Formal analysis, Data curation. **Coree Rhem:** Writing – review & editing, Writing – original draft, Project administration. **Perry N. Halkitis:** Writing – review & editing,

Writing – original draft, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Perry N. Halkitis reports financial support was provided by Merck Sharp & Dohme Corp. If there are other authors, they 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

To protect the confidentiality of our participants, we do not make data freely available. Data are housed at the Rutgers School of Public Health's Center for Health, Identity, Behavior and Prevention Studies (CHIBPS), and the data set may be made available upon written request to the Principal Investigators (KDK and PNH).

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