Mohana Mahfuz Prema
Econ 699 Capstone Proposal
Advisor: Professor Hasan Shahid

Preventive Vaccination Uptake by Self-Reported Sexual Orientation Among U.S. Adults: Evidence from IPUMS NHIS 2021–2024.

Abstract

This capstone examines preventive vaccination uptake by self-reported sexual orientation among U.S. adults using pooled IPUMS NHIS data from 2021–2024. The study compares heterosexual, gay/lesbian, and bisexual adults across HPV, hepatitis A, hepatitis B, influenza, tetanus/Td, COVID-19, shingles, and pneumococcal vaccination. Survey-weighted logistic regression models are used to estimate unadjusted and adjusted average marginal effects. Preliminary results show that vaccination patterns vary by vaccine type and sexual-orientation subgroup. This study provides recent national evidence on sexual-orientation differences in routine adult vaccination in the post-COVID period.

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1. Introduction

Vaccination is widely recognized as one of the most efficient and effective preventive health investments. Vaccines reduce the risk of illness, hospitalization, disability, and death, while also lowering medical spending, caregiver burden, and productivity losses (Ozawa et al., 2016; White, 2019; Blanchet Zumofen et al., 2022). Recent evidence from COVID-19 vaccination further demonstrates the large economic return and public health value of vaccines (Padula et al., 2021; Kirson et al., 2022; Freedman et al., 2023). Because vaccination can reduce disease transmission beyond the vaccinated individual, it generates positive externalities through broader spillover benefits to society (Arrow, 1963; Carpenter & Lawler, 2019). These private and social benefits provide an economic rationale for public vaccination programs and policies aimed at increasing coverage.

Despite these benefits, many adults remain unvaccinated for routine immunization. The CDC report from the 2022 National Health Interview Survey (NHIS) shows that only 22.8 percent of adults were up to date on all age-appropriate vaccines. Increasing immunization coverage is a core national objective highlighted by Healthy People 2030, which explicitly links higher vaccination rates to the long-term goal of mitigating infectious disease throughout the lifespan.

A large body of literature has examined how adult vaccination differs by demographic factors such as race, ethnicity, and gender. Racial and ethnic differences have been documented across

several adult vaccines, with Black and Hispanic adults often reporting lower coverage than White adults (Rangel et al., 2005; Lu et al., 2015; Granade et al., 2022; Peña et al., 2023). Gender differences have also been observed, although the direction of the difference varies across vaccines and measures of uptake or acceptance (Kini et al., 2022; Park & Kim, 2024). Together, this literature shows that subgroup differences are an important part of adult vaccination research.

Compared with race, ethnicity, and gender, sexual orientation has received less attention as a dimension of adult vaccination research, especially in health economics. This gap is partly due to limited data availability, inconsistent measurement of sexual orientation, and small subgroup sample sizes. These limitations make it difficult to study sexual minority adults separately by subgroup. Addressing this data gap is consistent with Healthy People 2030's emphasis on improving the health, safety, and overall well-being of LGBT individuals and underscores the need for better population-level data to inform effective health promotion strategies for this community.

There are several reasons to expect vaccination uptake to differ by sexual orientation. First, sexual minority adults may face different health risks and vaccine-related recommendations for some diseases. Second, sexual minority adults may experience barriers to healthcare, including stigma, discrimination, lack of culturally competent care, financial barriers, and lower trust in healthcare settings. Third, sexual minority adults may differ from heterosexual adults in socioeconomic status, employment, insurance coverage, health behaviors, and health status, all of which may influence access to preventive services.

This capstone uses pooled 2021–2024 IPUMS NHIS data to analyze preventive vaccination uptake by sexual orientation among U.S. adults. Comparing heterosexual, gay/lesbian, and bisexual adults, the study examines HPV, hepatitis A, hepatitis B, influenza, tetanus/Td, COVID-19, shingles, and pneumococcal vaccination coverage. It assesses whether orientation-based differences persist after adjusting for demographic, socioeconomic, health, and healthcare-access factors. Srivastav et al. (2019) provides the closest prior evidence on adult vaccination uptake by sexual orientation. This study uses a similar empirical approach but extends the literature by analyzing more recent post-COVID NHIS data and a broader set of adult vaccines. Given that recent vaccination literature often emphasizes COVID-19, this study provides updated, nationally representative evidence on routine and preventive adult vaccination differences by sexual orientation.

2. Literature Review

2.1. Adult Vaccination Behavior

Vaccination uptake is shaped by both Socio-economic and access-related factors. Socioeconomic factors such as education, family background, income, and employment are important because

they affect both health knowledge and the practical ability to obtain preventive care (Lleras-Muney, 2005; Cutler & Lleras-Muney, 2010; Epstein et al., 2009).

Adults may also face barriers related to healthcare access and insurance coverage which impact vaccination. Ellis and Manning (2007) used immunization as an example of preventive care to show that insurance coverage matters for prevention because individuals may underuse services that reduce future illness and medical costs. Similarly, the CDC's 2022 adult vaccination coverage summary reported lower coverage among adults without health insurance or a usual place for healthcare. Therefore, the likelihood of receiving vaccines by adults is influenced by multiple factors.

2.2. Socioeconomic and Health Dynamics of Sexual Minority Adults

Economic research shows that sexual minority adults differ from heterosexual adults in earnings, occupational sorting, and economic security. Gay men are often found to earn less than comparable heterosexual men, while lesbian women sometimes earn more than heterosexual women, suggesting that labor-market outcomes vary by both sexual orientation and gender (Antecol et al., 2008; Badgett et al., 2021; Drydakis, 2019; Sabia 2014). More broadly, Badgett et al. (2021, 2024) emphasize that LGBTQ+ populations differ from heterosexual and cisgender populations across human capital, family formation, labor-market outcomes, and economic security.

These labor-market differences are relevant to vaccination because income, employment stability, and employer-sponsored insurance may influence whether adults have affordable and regular access to preventive healthcare. Carpenter et al. (2020) show that the Affordable Care Act dependent coverage mandate increased health insurance coverage among young adults in same-sex couples, especially men ages 21–25, largely through employer-sponsored insurance. This evidence is relevant to the present study because insurance coverage is an important access pathway through which sexual minority adults may receive preventive care, including recommended adult vaccines.

Sexual minority adults also differ from heterosexual adults in health status, healthcare experiences, and exposure to stigma. Prior research documents higher burdens of poor mental health, substance use, HIV infection, smoking, heavy alcohol use, and other risk factors among sexual minority adults compared with heterosexual adults (Boehmer, 2002; Bostwick et al., 2010; Conron et al., 2010; Blosnich et al., 2014; Cochran et al., 2013; Gonzales et al., 2016; Gonzales & Henning-Smith, 2017; Gorman et al., 2015; Hatzenbuehler et al., 2008; Meyer, 1995). These patterns are not uniform across sexual minority subgroups. Pharr et al. (2019) find that bisexual adults, particularly bisexual women, often report poorer self-rated health, higher depression, smoking, heavy drinking, and greater economic insecurity compared with straight women and gay/lesbian adults.

Healthcare access and provider experience may further shape preventive service use among sexual minority adults. Studies show that sexual minorities are more likely to be uninsured and to delay or forgo medical care because of financial cost (Buchmueller & Carpenter, 2010; Dahlhamer et al., 2016; Gonzales & Blewett, 2014; Heck et al., 2006; Ponce et al., 2010). In addition, sexual and gender minorities may experience barriers in healthcare settings, including unequal treatment, lack of appropriate care, poor provider communication, lack of culturally competent care, and cis-heteronormative assumptions (Silva & Costa, 2020; Heer et al., 2023). Nguyen et al. (2024) further show that sexual and gender minority adults report higher levels of social risk factors, including financial strain and transportation barriers, which may affect access to preventive care. These barriers are relevant to vaccination because adult vaccine uptake often depends on access to healthcare, provider interaction, and the ability to obtain preventive services.

2.3. Vaccination Among Sexual Minority Adults

Vaccination may be especially relevant for some sexual minority subgroups and vaccine types. Gay, bisexual, and other men who have sex with men are at elevated risk for some vaccine-preventable diseases, including HPV, hepatitis A, and hepatitis B (CDC, 2024; HHS, 2020; Immunize.org, 2025; Meites et al., 2022; NICE, 2022). This concern fits within broader evidence that sexual and gender minority populations have been disproportionately affected by HIV, sexually transmitted infections, and STI-related cancers (Blondeel et al., 2016). Sexual orientation may therefore be associated with vaccination uptake through competing mechanisms: higher perceived risk or targeted recommendations may increase uptake for some vaccines, while economic insecurity, stigma, discrimination, or limited access to culturally competent care may reduce preventive service use.

Recent studies on vaccination by sexual orientation have focused heavily on COVID-19 vaccination and show that sexual-minority vaccination patterns are not uniform across subgroups. McNaghten et al. (2022), using the National Immunization Survey Adult COVID Module from August–October 2021, found that gay and lesbian adults had higher COVID-19 vaccination coverage than heterosexual adults, while bisexual adults had coverage closer to that of heterosexual adults. The study also showed important subgroup variation: among gay/lesbian and bisexual adults, men had higher vaccination coverage than women, and vaccination coverage was particularly low among non-Hispanic Black LGBT adults. Among non-Hispanic Black adults, gay/lesbian women and bisexual women had lower coverage than heterosexual women, suggesting that sexual-orientation differences may depend on both race/ethnicity and gender.

Park and Kim (2024) also examined COVID-19 vaccination using the U.S. Census Bureau Household Pulse Survey from 2021 to 2024. In contrast to McNaghten et al. (2022), their adjusted regression results showed that both gay/lesbian and bisexual adults had higher odds of COVID-19 vaccination than heterosexual adults. However, their main contribution was not only

the average sexual-orientation difference, but also the finding that pandemic-related socioeconomic hardships were associated with lower vaccine uptake and that these associations varied across sexual orientation and gender identity groups. This suggests that economic insecurity, household hardship, and social vulnerability may shape vaccination behavior differently within sexual and gender minority populations. Xu et al. (2024) similarly focused on COVID-19 testing and vaccination among youth and young adults ages 14–24. Their results showed differences in COVID-19 vaccination by age and race/ethnicity, but the study was limited to a younger online sample and does not provide the same broad adult comparison across routine vaccines.

Other recent work examines vaccination beyond COVID-19 but remains limited in scope or sample design. Polonijo and Vogelsang (2023) used 2020 Behavioral Risk Factor Surveillance System (BRFSS) data to study influenza and shingles vaccination among U.S. adults aged 50 and older and pneumococcal vaccination among adults aged 65 and older, by sexual orientation and gender identity.They found that vaccination differences vary by subgroup and vaccine type: transgender adults have lower uptake across all three vaccines, gay men are more likely than heterosexual men to receive flu and shingles vaccination, and bisexual women are less likely than heterosexual women to receive flu vaccination. Although this study provides nationally relevant evidence on routine adult vaccines, it focuses on older adults and examines only three vaccine outcomes.

Krause et al. (2024) studied LGBTQ+ adults in New Jersey and New York and examined uptake of several adult vaccines, including COVID-19, HPV, hepatitis A, hepatitis B, meningitis B, influenza, and shingles. They found that vaccine uptake varied substantially by vaccine type and by LGBTQ+ subgroup. However, because the study included only LGBTQ+ adults, it could not directly compare gay/lesbian or bisexual adults with heterosexual adults. Its regional focus on two states also limits the extent to which the findings can be generalized to all U.S. adults.

Hsieh (2024) provides especially relevant evidence on intersectional vaccination differences using NHIS data from 2013–2018, but the analysis focuses only on influenza vaccination. The study found that flu vaccination varied jointly by sexuality, gender, and race/ethnicity. White gay men had the highest predicted flu vaccination rate, while Black bisexual women had the lowest. More broadly, sexual-minority women had lower flu vaccination rates than heterosexual women across several racial and ethnic groups, whereas sexual-minority men often had similar or higher rates than heterosexual men. These findings suggest that sexual orientation should not be treated as a single uniform category; rather, vaccination differences may differ between gay/lesbian and bisexual adults and may also be shaped by gender and race/ethnicity. Together, these studies suggest that sexual orientation is relevant for vaccination uptake, but the association may differ by vaccine type, subgroup, gender, race/ethnicity, healthcare access, and socioeconomic context.

This capstone is most closely aligned with the work of Srivastav, O'Halloran, Lu, Williams, and Hutchins (2019), who used NHIS 2013–2015 data to examine differences in adult vaccination by self-identified sexual orientation. Their analysis examined several adult vaccines, including HPV, hepatitis A, hepatitis B, influenza, pneumococcal, tetanus, and shingles vaccination. They found that vaccination patterns differed by sexual orientation and vaccine type. For example, bisexual women had higher HPV vaccination coverage than heterosexual women. Gay men and bisexual women had higher hepatitis A and hepatitis B vaccination coverage than their heterosexual counterparts. In contrast, bisexual adults had lower influenza vaccination coverage than gay/lesbian and heterosexual adults. For several other vaccines, including pneumococcal, tetanus, and shingles vaccination, differences by sexual orientation were less consistent or not statistically significant after adjustment. In their multivariable logistic regression, health status and other behavioral traits did not show a consistent association with vaccination across all groups. However, characteristics generally associated with vaccination remained independently associated with the probability of being vaccinated even after controlling for sexual orientation.

2.4. Literature Gap and Contribution of This Study

Although adult vaccination research has examined differences by race, ethnicity, gender, insurance, and healthcare access, sexual orientation remains less developed as a dimension of vaccination research, especially in health economics. One reason is that sexual orientation has not been consistently measured in health surveillance data. Using both Web and PubMed searches, Patterson et al. (2017) identified 43 data sources that included sexual orientation or transgender-inclusive gender identity measures: 7 international sources and 36 U.S.-specific sources, including 21 national and 15 state or regional sources. However, few datasets followed best-practice measurement guidelines. Only 14% measured all three dimensions of sexual orientation—identity, behavior, and attraction—and none used the recommended two-step gender identity measure based on sex assigned at birth and current gender identity (Patterson et al., 2017). In addition, because sexual minority adults represent a relatively small share of the population, researchers often face small subgroup sample sizes. As a result, some studies combine sexual minority adults into one broad category to improve statistical power, but this approach can obscure important differences between gay/lesbian and bisexual adults.

The existing post-COVID literature on vaccination by sexual orientation remains limited because much of the recent evidence focuses on COVID-19 vaccination rather than a broader set of routine adult vaccines. As a result, less is known about whether sexual-orientation differences persist across vaccines such as HPV, hepatitis A, hepatitis B, influenza, tetanus, shingles, and pneumococcal vaccination. Srivastav et al. (2019) is the study most closely related to this capstone because it also uses NHIS data and examines multiple adult vaccines by self-reported sexual orientation. However, the present analysis differs from Srivastav et al. in both period and design: it uses more recent pooled IPUMS NHIS data from 2021–2024 and focuses on overall sexual orientation differences rather than replicating their gender-stratified and high-risk

subgroup structure. In reviewing the literature, I did not identify any recent nationally representative study that compares heterosexual, gay/lesbian, and bisexual adults across multiple routine adult vaccines in the post-COVID period.

This capstone addresses that gap in three ways. First, it uses recent pooled IPUMS NHIS 2021–2024 data to examine adult vaccination uptake in the post-COVID period. Second, it examines vaccination uptake separately for heterosexual, gay/lesbian, and bisexual adults rather than combining sexual minority adults into one broad category. Third, it compares sexual-orientation differences across multiple adult vaccines and estimates both unadjusted and adjusted survey-weighted models. By controlling for demographic, socioeconomic, healthcare access, and health-related characteristics, the analysis examines whether sexual orientation differences persist after accounting for key observed covariates. In doing so, the study contributes recent evidence to the literature on adult vaccination, LGBTQ+ health, and preventive health behavior from a health economics perspective.

3. Data and Methodology

3.1. Survey Description

This study uses pooled 2021–2024 data from IPUMS NHIS, a harmonized version of the National Health Interview Survey. The NHIS is an annual, nationally representative household survey of the civilian, noninstitutionalized U.S. population. It collects information on health status, health behaviors, healthcare access, insurance coverage, demographic characteristics, and socioeconomic conditions. IPUMS Health Surveys harmonizes NHIS variables across years and allows researchers to create customized data extracts for analysis. This study uses the Sample Adult files because adult vaccination outcomes and self-reported sexual orientation are measured for sampled adults. Pooling 4 years of combined data increases the analytic sample size for sexual minority adults and supports comparisons of vaccination uptake among heterosexual, gay/lesbian, and bisexual adults. The sample size for this study was 107,498 adults aged ⩾ 19 years.

3.2. Vaccine Variables

The primary outcome variables are binary indicators of adult vaccination uptake, coded as 1 if the respondent reported receiving the vaccine and 0 if the respondent reported not receiving it. Respondents with missing, refused, don't know, or not ascertained responses are excluded from the vaccine-specific analytic sample. This analysis includes eight vaccination outcomes: influenza, COVID-19, tetanus/Td, HPV, hepatitis A, hepatitis B, shingles, and pneumococcal vaccination. This study follows the CDC adult immunization schedule for adults aged 19 years and older to define broad routine adult vaccination outcomes. Detailed vaccine-specific clinical indications and narrowly defined risk-based recommendations are not applied because eligibility

for some vaccines depends on individualized clinical assessment and provider–patient interaction, which are not fully captured in the IPUMS NHIS survey data.

The analytic sample varies across vaccine outcomes because CDC adult vaccination recommendations differ by vaccine type and age group; restricting each outcome to the relevant age range helps align the analysis with the population for whom the vaccine is routinely recommended. HPV vaccination is examined among young adults aged 19–26[1], while hepatitis B vaccination is examined among adults aged 19–59[2]. Influenza, COVID-19, and tetanus/Td vaccination are examined among adults aged 19 and older. Tetanus/Td vaccination reflects the routine adult booster recommendation, with Td/Tdap recommended every 10 years for adults. Shingles and pneumococcal vaccination are examined among adults aged 50 and older[3,4]. Hepatitis A is included as an adult vaccination outcome available in NHIS, but the analysis does not apply detailed risk-based eligibility criteria.

In the analysis, HPV, hepatitis A, hepatitis B, shingles, and pneumonia vaccination indicate whether the respondent has ever received the respective vaccine. Influenza vaccination captures whether the respondent received a flu vaccine within the past 12 months. Tetanus/Td vaccination indicates whether the respondent received a tetanus/Td shot in the past 10 years, excluding tetanus vaccination received during pregnancy. COVID-19 vaccination is defined as whether the respondent has ever received a COVID-19 vaccine. Because vaccination questions were not collected in every NHIS survey year, HPV and tetanus/Td vaccination are analyzed using 2022 data only, hepatitis A vaccination is analyzed using 2021 and 2024 data, and hepatitis B vaccination is analyzed using 2021 and 2023 data. Therefore, sample sizes vary across vaccine outcomes.

3.3. Sexual Orientation Variable

This is the primary independent variable of interest. The sexual orientation in the dataset is used to capture the self-identified sexual orientation of sample adults aged 19 and older by asking, "Which of the following best represents how you think of yourself?" Respondents were given options including "gay" or "lesbian," "straight, that is, not lesbian or gay," "bisexual," "something else," and "I don't know the answer." The wording of the question was slightly tailored based on

[1] The Advisory Committee on Immunization Practices (ACIP) recommends routine HPV vaccination at ages 11 or 12, with vaccination allowed to begin at age 9, and catch-up vaccination through age 26 for those not adequately vaccinated. Because HPV vaccination is not routinely recommended for all adults older than age 26, and vaccination for adults ages 27–45 is based on shared clinical decision-making. This analysis restricts the HPV sample to young adults ages 19–26

[2] ACIP recommends universal HepB vaccination for adults aged 19–59 years, and adults aged ≥60 years with risk factors for hepatitis B.

[3] ACIP recommends recombinant 2 doses of Shingles vaccine (Now RZV; Shingrix) for adults aged 50 years and older, and for adults aged 19 years and older who are or will be immunodeficient or immunosuppressed.

[4] Prior to October 2024, pneumococcal vaccine (PCV) was recommended for adults aged 19–64 with specific risk conditions and all those aged ≥65. On October 23, 2024, the ACIP expanded this to include a single PCV dose for all adults aged ≥50 who are PCV-naïve or have an unknown vaccination history. Risk-based recommendations for adults aged 19–49 remain unchanged.

gender, with men asked about being "gay" or "straight, that is, not gay," and women asked about being "lesbian or gay" or "straight, that is, not lesbian or gay." It is important to note a data limitation: while follow-up questions were asked to those who chose "something else" or "I don't know the answer," these detailed responses are not included in the publicly available data due to sample size constraints. Respondents who selected "something else" or "I don't know the answer" were classified as missing data and thus excluded from this analysis.

3.4. Demographics, Socio-Economic and Health-related Variables

Consistent with prior health economics and epidemiological literature, this study incorporates a comprehensive set of covariates capturing demographic characteristics, socio-economic status, health conditions, health behaviors, and healthcare access.

Demographic variables include age group (19-26, 27-49, 50–64, and ≥65 years), gender (male, female), and race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and non-Hispanic other/multiple races).

Socio-economic characteristics comprise educational attainment (less than high school, high school/GED, and college or higher), employment status (employed vs. not employed), and poverty level. *Employment status* classifies whether sample adults were active in the workforce last week (including seasonal, contract, or paid work) or were away from work temporarily. The "No" category encompasses individuals outside the labor force as well as those who are unemployed but actively seeking work. *Poverty level* is defined using the ratio of family income to the federal poverty threshold for the given year. Individuals are classified as below poverty if the ratio is less than 1, at or near poverty if the ratio is between 1 and 2, and above poverty if the ratio is greater than 2.

Healthcare access variables include health insurance coverage (insured vs. uninsured) and having a usual place for healthcare (yes/no). Health status and clinical conditions are measured using self-reported overall health (excellent vs. other), body mass index (BMI) (normal/underweight, overweight, obese), and the presence of chronic conditions, including asthma, diabetes, heart disease, and disability status. *Disability status* is defined by the Washington Group Short Set Composite Disability Indicator, which signifies the presence of a disability related to challenges in vision, hearing, ambulation, communication, self-care (washing or dressing), or cognition (remembering or concentrating).

Finally, *travel* history is incorporated as a proxy for exposure-related risk, which is particularly relevant for vaccines such as hepatitis A and hepatitis B. Individuals reporting travel to high-risk regions are more likely to be recommended for specific vaccinations. This variable indicates whether the respondent has traveled to any country other than Canada, Japan, Australia, New Zealand, or Europe since 1995.

3.5. Econometric Framework

This study estimates two survey-weighted logistic regression models for each vaccine outcome. *The first model* examines the unadjusted association between self-reported sexual orientation and vaccination uptake. *The second model* adds demographic, socioeconomic, healthcare-access, and health-related covariates to examine whether sexual-orientation differences persist after accounting for observed characteristics. Results are reported as average marginal effects (AMEs), which are easier to interpret than log-odds because they represent changes in vaccination probability.

Model 1: $Pr(Y_{iv} = 1 \mid SO_i) = \Lambda(\alpha_v + \beta_v SO_i)$

where, Y_{iv} is a binary indicator equal to 1 if individual i received vaccine v and 0 otherwise; SO_i represents self-reported sexual orientation categories, with heterosexual respondents as the reference group; α_v is the vaccine-specific intercept; β_v captures the association between sexual orientation and vaccination uptake for vaccine v; and $\Lambda(.)$ is the logistic cumulative distribution function.

The unadjusted average marginal effect (AME) for the sexual-orientation category (k) is:

$AME_{k,v} = (1/N_v) \Sigma_{i=1}^{Nv} [Pr(Y_{iv} = 1 \mid SO_i = k) - Pr(Y_{iv} = 1 \mid SO_i = heterosexual)]$

AMEs represent discrete changes in predicted vaccination probabilities relative to the heterosexual reference group.

Model 2: $Pr(Y_{iv}=1 \mid SO_i, Z_i) = \Lambda(\alpha_v + \beta_v SO_i + \delta_v Z_i)$

Model 2 extends Model 1 by adding Zi, which is a vector of control variables included in the vaccine-specific model. δ_v is the vector of coefficients for these controls. These controls include demographic, socioeconomic, healthcare-access, and health-related characteristics. All other terms are defined as above for Model 1.

The adjusted average marginal effect (AME) for category k is:

$AME_{k,v} = (1/N_v) \Sigma_{i=1}^{Nv} [Pr(Y_{iv} = 1 \mid SO_i = k, Z_i) - Pr(Y_{iv} = 1 \mid SO_i = heterosexual, Z_i)]$

The adjusted AME reports whether the probability of receiving vaccine differs between gay/lesbian or bisexual adults and heterosexual adults, even after holding observed covariates constant. For categorical variables, including sexual orientation, AMEs are interpreted as discrete changes in predicted probability relative to the reference group.

4. Results

4.1. Descriptive Statistics

Table 1 and Table 2 represent the descriptive statistics of the survey participants. Table 1 presents the percentage distribution (weighted) of selected demographic, socioeconomic, healthcare-access, health-status, and health-condition characteristics among adults aged 19 years and older by self-reported sexual orientation. For categorical variables, the table reports weighted percentage distributions and unweighted sample counts.

In the pooled IPUMS NHIS 2021–2024 sample among 107,498 individuals, 95.29% of adults identified as heterosexual, 2.07% as gay/lesbian, and 2.64% as bisexual, indicating that the bisexual population share was slightly larger than the gay/lesbian share. Bisexual adults were more concentrated in younger age groups, particularly ages 19–26, than heterosexual and gay/lesbian adults, while heterosexual adults had a larger share of respondents aged 65 and older. Gender composition also differed across groups: gay/lesbian adults were more likely to be male, whereas bisexual adults were more likely to be female. For race and ethnicity, non-Hispanic White adults made up the largest share in all three sexual-orientation groups, followed by Hispanic adults and then non-Hispanic Black adults.

Gay/lesbian adults had higher educational attainment and a higher employment rate than heterosexual adults[5]. In contrast, bisexual adults had higher poverty and lower access to healthcare, including lower rates of having a usual place for care and health insurance.

Health characteristics also differed by sexual orientation. Gay/lesbian and bisexual adults reported higher asthma prevalence than heterosexual adults, and bisexual adults reported higher disability. In contrast, heterosexual adults had higher rates of heart disease and diabetes, likely reflecting their older age distribution.

Table 2 presents survey-weighted, unadjusted vaccination coverage(%) among U.S. adults by self-identified sexual orientation. The results show substantial variation in vaccination uptake across sexual-orientation groups, and the direction of the differences varies by vaccine type.

Overall, among 1973 individuals aged 19–26 years, 46.42% were vaccinated against HPV. Bisexual adults had the highest HPV uptake at 69.50%, compared with 53.61% among gay/lesbian adults and 43.20% among heterosexual adults. The bisexual estimate was significantly higher than the heterosexual estimate and also significantly different from the

[5] This analysis stratified employment by age to see if age composition influenced sexual orientation-based differences. Findings suggest the higher non-employment rate among heterosexual respondents is partly due to a larger retirement-age population among heterosexual respondents; they had the lowest employment rate among those 65 and older. However, patterns varied: gay and lesbian respondents outpaced heterosexuals in every age group. At the same time, bisexual adults had lower employment rates than heterosexual adults among key working-age groups, particularly ages 27–49 and 50–64. Thus, while age composition partly explains heterosexual employment trends, it does not account for the disadvantage seen in working-age bisexual respondents.

gay/lesbian estimate. The gay/lesbian HPV estimate should be interpreted cautiously because the gay/lesbian subgroup has a small sample size and a wide confidence interval.

For hepatitis A and hepatitis B vaccination, both sexual minority groups had higher unadjusted vaccination coverage than heterosexual adults. Hepatitis A vaccination coverage rate was significantly higher among gay/lesbian adults and bisexual adults than among heterosexual adults (42.86% and 45.05%, respectively). Hepatitis B vaccination showed a similar pattern, with significantly higher uptake among gay/lesbian adults and bisexual adults than among heterosexual adults (59.90% and 51.65%, respectively). For hepatitis B, the gay/lesbian estimate was also significantly higher than the bisexual estimate.

For influenza vaccination, the unadjusted pattern differed from hepatitis A and hepatitis B. Gay/lesbian adults had a significantly higher flu vaccination rate (54.12%) than heterosexual adults; in contrast, bisexual adults had a significantly lower rate (41.37%) than both heterosexual and gay/lesbian adults. COVID-19 vaccination was higher among both gay/lesbian and bisexual adults than among heterosexual adults, but the gay/lesbian estimate remained significantly higher than the bisexual estimate (88.32% vs 80.50%).

For tetanus/Td vaccination, gay/lesbian adults had a significantly higher unadjusted vaccination proportion than heterosexual adults, while bisexual adults did not differ significantly from heterosexual adults.

For shingles and pneumococcal vaccination, gay/lesbian adults again had a higher uptake than heterosexual adults. However, the vaccination rate among bisexual adults was significantly lower than that of gay/lesbian adults for both of these vaccines. Bisexual adults also had a lower vaccination coverage for Pneumonia than the heterosexual population, although the estimate was not statistically significant. Figure 1 and Figure 2 visually summarize the survey-weighted vaccination proportions (%) from Table 2, highlighting differences in vaccine uptake across sexual orientation groups.

4.2. Results From Logistic Regression

Tables 3 and 4 extend the descriptive evidence from Tables 1 and 2 by estimating average marginal effects from survey-weighted logistic regression models. While Table 1 describes how respondent characteristics differ by sexual orientation, and Table 2 reports unadjusted vaccination proportions, Tables 3 and 4 quantify the association between sexual orientation and vaccination uptake in a logistic regression framework. This allows the study to express the difference between gay/lesbian or bisexual adults and heterosexual adults as a percentage-point difference in the probability of vaccination uptake, with statistical significance and confidence intervals.

Table 1. Descriptive Statistics of the survey participants aged 19 years and older, categorized by demographic characteristics, socio-economic factors, health conditions, health status, healthcare access, and self-identified sexual orientation, derived from IPUMS NHIS 2021-2024. *(Sample values are unweighted counts. Weighted % values are survey-weighted column percentages.)*

	Heterosexual		Gay/Lesbian		Bisexual	
	Sample	**Weighted %**	**Sample**	**Weighted %**	**Sample**	**Weighted %**
Overall	107,498	95.29	2,436	2.07	2,483	2.64
Age group						
19-26	7,717	12.21	289	20.50	796	44.34
27-49	35,981	38.50	1,053	45.26	1,281	46.87
50-64	27,033	25.42	632	22.59	230	6.22
65 and older	35,793	23.86	433	11.65	128	2.58
Gender						
Male	49,378	49.32	1,427	57.90	634	24.96
Female	58,119	50.68	1,006	42.10	1,846	75.04
Race/Ethnicity						
Non-Hispanic White	71,918	62.30	1,677	66.42	1,693	68.73
Non-Hispanic Black	11,246	11.54	219	10.76	208	9.04
Hispanic	15,338	17.42	353	14.97	350	13.78
Non-Hispanic Other	8,996	8.73	187	7.85	232	8.44
Education level						
Less than HS	9,181	10.35	61	3.68	121	6.34
HS and GED	42,992	42.88	776	37.68	1,085	51.67
College and above	54,870	46.77	1,591	58.64	1,265	41.99
Employment status[a]						
Employed	61,263	62.85	1,730	74.03	1,804	72.00
Not employed	45,954	37.15	705	25.97	675	28.00
Poverty level[b]						
Above poverty	77,832	72.86	1,917	78.32	1,619	64.92
At or near poverty	18,966	17.54	323	13.22	500	20.68
Below poverty	10,700	9.61	196	8.45	364	14.39
Self-selected health status						
Excellent/very good	58,988	56.65	1,437	60.66	1,294	52.29
Other	48,471	43.35	998	39.34	1,189	47.71
BMI status						

	Heterosexual		Gay/Lesbian		Bisexual	
	Sample	Weighted %	Sample	Weighted %	Sample	Weighted %
Normal and below weight	34,400	32.42	859	36.96	921	38.40
Overweight	36,326	34.24	781	30.78	631	24.46
Obese	34,651	33.34	770	32.25	894	37.14
Usual place for healthcare						
Yes	98,102	89.95	2,225	90.83	2,140	85.13
No	9,330	10.05	210	9.17	342	14.87
Health insurance						
Yes	99,521	90.81	2,293	93.52	2,234	88.76
No	7,720	9.19	140	6.48	241	11.24
Asthma						
Yes	14,971	14.03	462	20.00	650	27.25
No	92,440	85.97	1,974	80.00	1,831	72.75
Heart disease						
Yes	6,938	5.12	97	3.05	47	1.14
No	100,260	94.88	2,335	96.95	2,432	98.86
Diabetes						
Yes	12,086	10.03	186	6.29	109	4.05
No	95,331	89.97	2,248	93.71	2,373	95.95
Disability						
Yes	11,370	9.03	220	8.88	311	12.91
No	96,126	90.97	2,216	91.12	2,172	87.09
Travel						
Yes	33,055	40.77	901	46.74	794	36.69
No	49,596	59.23	961	53.26	1,119	63.31

Note:

1. [a] Employment status classifies whether sample adults were active in the workforce last week (including seasonal, contract, or paid work) or were away from work temporarily. The "No" category encompasses individuals outside the labor force as well as those who are unemployed but actively seeking work.
2. [b] Poverty level is defined using the ratio of family income to the federal poverty threshold for the given year. Individuals are classified as below poverty if the ratio is less than 1, at or near poverty if the ratio is between 1 and 2, and above poverty if the ratio is greater than 2.
3. This analysis also stratified employment by age to see if age composition influenced sexual orientation-based differences. Findings suggest the higher non-employment rate among heterosexual respondents is partly due to a larger retirement-age population among heterosexual respondents; they had the lowest employment rate among those 65 and older. However, patterns varied: gay and lesbian respondents outpaced heterosexuals in every age group. At the same time, bisexual adults had lower employment rates than heterosexual adults among key working-age groups, particularly ages 27–49 and 50–64. Thus, while age composition partly explains heterosexual employment trends, it does not account for the disadvantage seen in working-age bisexual respondents.

Table 2. Survey-weighted unadjusted vaccination proportions (%) of selected vaccines among U.S. adults by self-identified sexual orientation, IPUMS NHIS 2021-2024. *(Sample values are unweighted counts. Weighted proportions are survey-weighted percentages with 95% confidence intervals.)*

Vaccines	Sexual Orientation							
	Overall		Heterosexual		Gay/Lesbian		Bisexual	
	N	Weighted proportion % (95% CI)[c]	N	Weighted proportion % (95% CI)	N	Weighted proportion % (95% CI)	N	Weighted proportion % (95% CI)
HPV[d] 19-26	1,973	46.42 (43.79, 49.05)	1,564	43.20 (40.32, 46.09)	63	53.61 (39.10, 68.12)	183	**69.50**[a***,b*] (61.90, 77.09)
Hepatitis A 19+	54,012	26.64 (25.99, 27.30)	49,686	25.82 (25.16, 26.48)	1,141	**42.86**[a***] (39.13, 46.59)	1,133	**45.05**[a***] (41.45, 48.65)
Hepatitis B 19-59	26,322	40.04 (39.18, 40.90)	23,906	39.24 (38.36, 40.13)	665	**59.90**[a***] (55.28, 64.51)	658	**51.65**[a***, b***] (47.28, 56.03)
Flu 19+	116,002	46.86 (46.25, 47.46)	106,113	47.03 (46.41, 47.64)	2,397	**54.12**[a***] (51.38, 56.86)	2,420	**41.37**[a***, b***] (38.94, 43.80)
Tetanus (Td) 19+	25,265	58.82 (57.78, 59.85)	22,952	58.83 (57.75, 59.91)	530	**66.36**[a***] (61.59, 71.12)	514	61.77 (56.78, 66.76)
COVID-19 19+	108,607	77.61 (77.01, 78.22)	99,357	77.36 (76.74, 77.97)	2,227	**88.32**[a***] (86.48, 90.15)	2,299	**80.50**[a***, b***] (78.32, 82.68)
Shingles 50+	65,894	38.21 (37.52, 38.90)	62,140	38.13 (37.43, 38.83)	1,057	**52.53**[a***] (48.99, 56.07)	352	**38.67**[b***] (32.81, 44.52)
Pneumonia 50+	65,266	41.58 (41.02, 42.14)	61,536	41.59 (41.02, 42.16)	1,038	**45.59**[a**] (42.08, 49.09)	343	**36.66**[b**] (30.23, 43.10)

Note:

1. [a] **** p<0.01, ** p<0.05, * p<0.1*, comparing against heterosexual.
2. [b] **** p<0.01, ** p<0.05, * p<0.1*, comparing against gay/ lesbian.
3. [c] CI is the confidence interval.
4. The vaccine age group is based on the CDC-recommended routine vaccination for adults and excludes special situations: Recommended Vaccinations for Adults
5. [d] Data on the Human Papillomavirus (HPV) vaccine were available only for 2022. Due to a comparatively small sample size for the subgroup, the HPV vaccination estimate for gay or lesbian adults between the ages of 19 and 26 is less precise. This results in a broader confidence interval and a larger standard error; therefore, these findings should be interpreted with caution.

Figure 1: Survey-weighted Unadjusted Vaccination Coverage by Sexual Orientation, Part 1

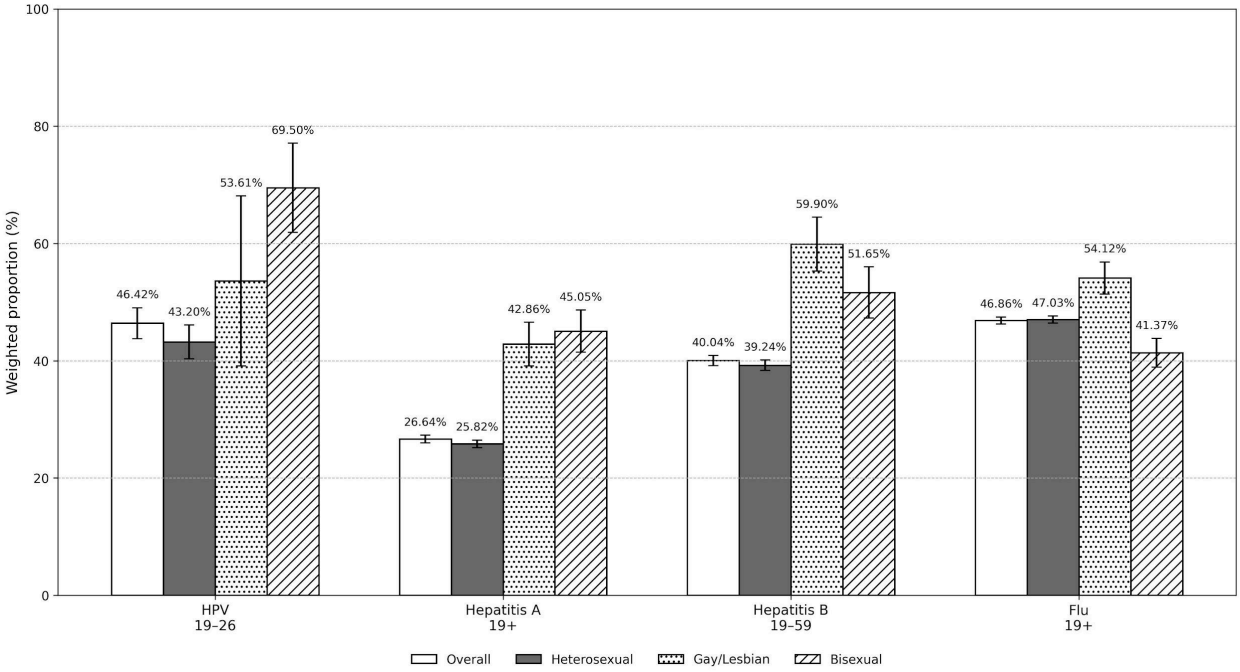

Figure 2: Survey-weighted Unadjusted Vaccination Coverage by Sexual Orientation, Part 2

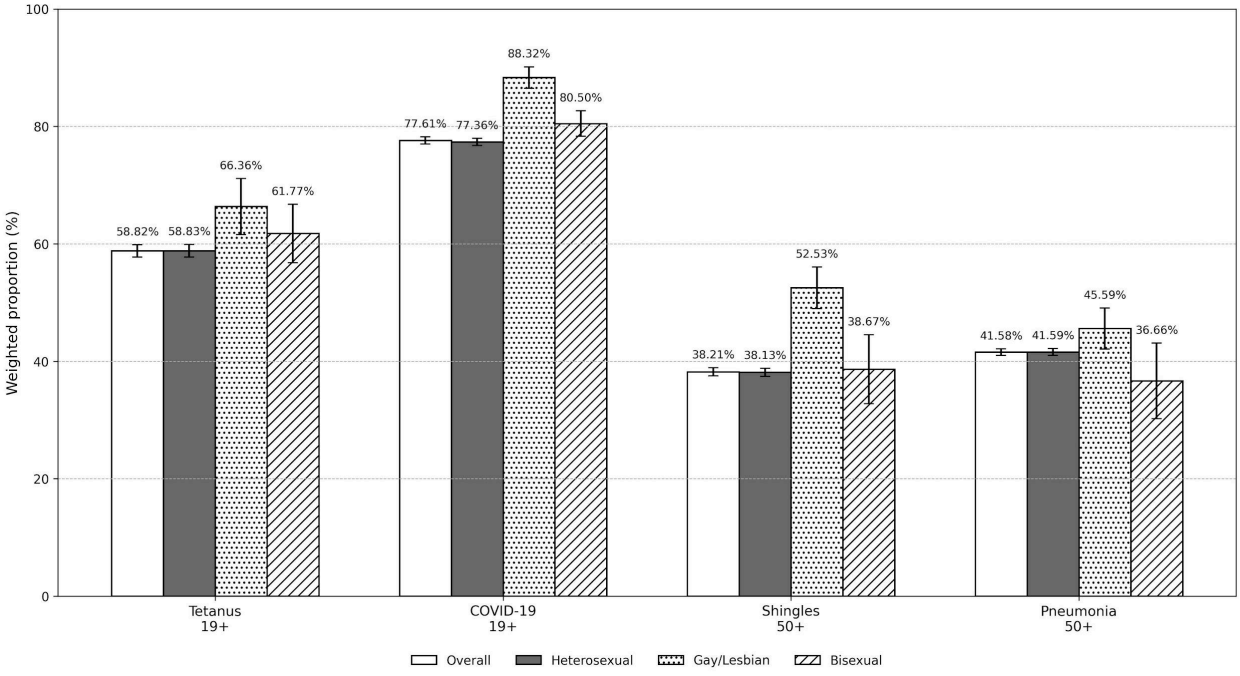

Table 3 presents Model 1; the baseline specification without controlling for individual covariates. In this bivariate model, sexual orientation is the only explanatory variable. In the unadjusted

model, gay or lesbian adults have significantly higher vaccination uptake than heterosexual adults for most vaccine outcomes. For the hepatitis A vaccine, the average marginal effect is 0.170, which indicates that the probability of receiving a hepatitis A vaccination is, on average, 17.0 percentage points higher for individuals in the gay/lesbian group compared to those in the heterosexual group, and significant at the 1% level. Similarly, for the hepatitis B vaccination, there is a 20.7 percentage point higher probability for gay/lesbian individuals to vaccinate relative to heterosexual adults, significant at the 1% level.

Gay or lesbian adults also have significantly higher uptake for flu, tetanus, COVID-19, shingles, and pneumonia vaccination. The HPV estimate is positive but not statistically significant, indicating that the baseline model does not provide sufficient evidence of a difference in HPV vaccination for gay or lesbian adults.

For bisexual adults, the unadjusted model shows significant positive differences for HPV, hepatitis A, hepatitis B, and COVID-19 vaccination. The AME for HPV is 0.263, meaning a 26.3 percentage point higher probability of receiving HPV vaccination for bisexuals relative to heterosexual adults, significant at the 1% level. The AMEs for hepatitis A and hepatitis B are 0.192 and 0.124, respectively, also significant at the 1% level. In contrast, the flu AME is -0.057, meaning a 5.7 percentage point decrease in flu vaccination relative to heterosexual adults, significant at the 1% level. The estimates for tetanus, shingles, and pneumonia vaccination are not statistically significant.

Table 4 presents the adjusted specification (Model 2), which conditions on observable covariates including demographic characteristics, socioeconomic status, healthcare access, health insurance, and selected health conditions. This adjusted model shows whether sexual-orientation differences remain after accounting for factors such as age, gender, race and ethnicity, education, employment, poverty status, usual place for healthcare, health insurance, smoking, alcohol use, and selected health conditions. Therefore, Table 4 helps distinguish raw group differences from differences that persist after conditioning on observable characteristics.

After adjustment, gay or lesbian adults remain significantly more likely than heterosexual adults to have several adult vaccines. The hepatitis B AME is 0.164, meaning on average a 16.4 percentage point higher probability of receiving the hepatitis B vaccine relative to comparable heterosexual adults, significant at the 1% level. The shingles AME is 0.129, meaning a 12.9 percentage point increase, and the COVID-19 AME is 0.111, meaning an 11.1 percentage point increase. Gay or lesbian adults also have significantly higher adjusted uptake for hepatitis A, flu, and pneumonia vaccination. The HPV and tetanus estimates are positive but not statistically significant after covariate adjustment.

For bisexual adults, the adjusted estimates remain significant for the HPV vaccine, hepatitis A, hepatitis B, flu, and COVID-19 vaccination. The HPV AME is 0.180, meaning that bisexual adults have an 18.0 percentage point higher likelihood of being vaccinated for HPV relative to the otherwise comparable heterosexual adults, holding covariates constant. The COVID-19 AME

is 0.092, meaning a 9.2 percentage point increase, and the hepatitis A AME is 0.080, meaning an 8.0 percentage point increase. The hepatitis B estimate is smaller and only marginally significant, which is different from unadjusted Model 1. The adjusted estimates for tetanus, shingles, and pneumonia vaccination are not statistically significant.

Table 3: Average Marginal Effects of Sexual Orientation on Vaccination Uptake, Unadjusted (Model 1), data from IPUMS NHIS 2021-2024.

Sexual Orientation	HPV (19-26)	Hepatitis A (19+)	Hepatitis B (19-59)	Flu (19+)	Tetanus (Td) (19+)	COVID-19 (19+)	Shingles (50+)	Pneumonia (50+)
	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)
Heterosexual	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group
Gay or Lesbian	0.104 (0.075) [-0.044, 0.252]	0.170*** (0.019) [0.133, 0.208]	0.207*** (0.024) [0.160, 0.253]	0.071*** (0.014) [0.044, 0.098]	0.075*** (0.025) [0.027, 0.124]	0.110*** (0.009) [0.091, 0.128]	0.144*** (0.018) [0.108, 0.180]	0.040** (0.018) [0.004, 0.075]
Bisexual	0.263*** (0.041) [0.182, 0.344]	0.192*** (0.018) [0.156, 0.228]	0.124*** (0.022) [0.080, 0.168]	-0.057*** (0.012) [-0.080, -0.033]	0.029 (0.026) [-0.021, 0.080]	0.031*** (0.011) [0.010, 0.053]	0.005 (0.030) [-0.053, 0.064]	-0.049 (0.033) [-0.113, 0.015]
Analytic Subpopulation N	1810	51,960	25, 229	110, 930	23, 996	103, 883	63, 549	62, 917

Notes:

1. AMEs are average marginal effects from survey-weighted logistic models. Heterosexuals are the reference group.
2. Standard errors are shown in parentheses, and 95% confidence intervals are shown in brackets.
3. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
4. Analyses are restricted to survey years in which each vaccination variable was available; therefore, sample sizes differ across the vaccines.
5. Data on the Human Papillomavirus (HPV) vaccine were available only for 2022. Due to a comparatively small sample size for the subgroup, the HPV vaccination estimate for gay or lesbian adults between the ages of 19 and 26 is less precise. This results in a broader confidence interval and a larger standard error; therefore, these findings should be interpreted with caution.
6. Hepatitis A data were available in 2021 and 2024.
7. Hepatitis B data were available in 2021 and 2023
8. Data on the Tetanus vaccine were available only for 2022.
9. Analyses are restricted to survey years in which each vaccination variable was available; therefore, sample sizes vary by vaccination.

The comparison between Tables 3 and 4 suggests that observable characteristics explain part, but not all, of the raw differences in vaccination uptake by sexual orientation. A notable change appears for flu vaccination among bisexual adults. In the unadjusted model (Model 1 and Table

3), the AME is -0.057, indicating a 5.7 percentage point decrease relative to heterosexual adults. After controlling for covariates (Model 2 and Table 4), the AME becomes 0.037, indicating a 3.7 percentage point increase in the probability of receiving the flu vaccine. This reversal suggests that the negative raw difference was influenced by compositional differences between bisexual and heterosexual adults rather than a lower adjusted association with flu vaccination.

Table 4: Adjusted Average Marginal Effects (Model 2) from Survey-Weighted Logistic Regression Models of Vaccination Uptake, IPUMS NHIS 2021-2024.

	HPV (19–26)	Hepatitis A (19+)	Hepatitis B (19–59)	Flu (19+)	Tetanus (Td) (19+)	COVID- 19 (19+)	Shingles (50+)	Pneumonia (50+)
	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)
Sexual Orientation								
Heterosexual	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group
Gay or Lesbian	0.036 (0.069) [-0.100,0.171]	0.105*** (0.017) [0.070,0.139]	0.164*** (0.023) [0.119,0.209]	0.092*** (0.012) [0.067,0.116]	0.039 (0.025) [-0.010,0.088]	0.111*** (0.009) [0.094,0.129]	0.129*** (0.017) [0.096,0.162]	0.083*** (0.015) [0.053,0.113]
Bisexual	0.180*** (0.041) [0.100,0.259]	0.080*** (0.016) [0.048,0.112]	0.043* (0.023) [-0.003,0.089]	0.037*** (0.011) [0.015,0.059]	0.030 (0.026) [-0.021,0.081]	0.092*** (0.008) [0.076,0.109]	0.046 (0.028) [-0.010,0.101]	-0.003 (0.026) [-0.054,0.048]
Age group								
19-26	—	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	—	—
27-49	—	-0.130*** (0.011) [-0.152,-0.108]	-0.122*** (0.014) [-0.151,-0.094]	0.013* (0.007) [-0.000,0.027]	-0.001 (0.014) [-0.029,0.027]	0.005 (0.007) [-0.008,0.018]	—	—
50-64	—	-0.238*** (0.012) [-0.261,-0.215]	-0.243*** (0.015) [-0.272,-0.213]	0.107*** (0.007) [0.092,0.121]	0.000 (0.016) [-0.030,0.031]	0.106*** (0.007) [0.092,0.120]	Reference Group	Reference Group
65 and above	—	-0.286*** (0.012) [-0.310,-0.263]	—	0.277*** (0.008) [0.261,0.292]	-0.056*** (0.016) [-0.087,-0.024]	0.184*** (0.007) [0.170,0.198]	0.175*** (0.005) [0.165,0.185]	0.336*** (0.005) [0.326,0.347]
Gender								
Male	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group
Female	0.179*** (0.026) [0.129,0.230]	0.017*** (0.005) [0.007,0.027]	0.067*** (0.008) [0.052,0.082]	0.056*** (0.004) [0.048,0.063]	-0.017** (0.008) [-0.033,-0.001]	0.012*** (0.003) [0.006,0.019]	0.015*** (0.004) [0.007,0.023]	0.036*** (0.004) [0.029,0.043]
Race/Ethnicity								
Non-Hispanic White	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group
Non-Hispanic Black	-0.056 (0.041) [-0.136,0.025]	-0.019** (0.008) [-0.035,-0.003]	-0.068*** (0.013) [-0.093,-0.044]	-0.057*** (0.006) [-0.069,-0.044]	-0.172*** (0.013) [-0.198,-0.146]	0.030*** (0.006) [0.018,0.042]	-0.081*** (0.007) [-0.095,-0.066]	-0.050*** (0.006) [-0.062,-0.038]
Hispanic	-0.004 (0.030) [-0.063,0.055]	0.001 (0.008) [-0.015,0.016]	-0.041*** (0.011) [-0.062,-0.020]	0.001 (0.007) [-0.012,0.014]	-0.074*** (0.013) [-0.098,-0.049]	0.108*** (0.005) [0.099,0.117]	-0.034*** (0.008) [-0.051,-0.018]	-0.075*** (0.007) [-0.089,-0.062]
Non-Hispanic Other	0.020 (0.038) [-0.056,0.095]	0.039*** (0.010) [0.020,0.058]	0.032** (0.013) [0.007,0.057]	0.057*** (0.007) [0.043,0.071]	-0.078*** (0.014) [-0.105,-0.051]	0.120*** (0.006) [0.109,0.131]	0.012 (0.010) [-0.007,0.032]	-0.051*** (0.008) [-0.066,-0.036]
Education level								
Less than HS	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group

	HPV (19–26)	Hepatitis A (19+)	Hepatitis B (19–59)	Flu (19+)	Tetanus (Td) (19+)	COVID- 19 (19+)	Shingles (50+)	Pneumonia (50+)
	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)
HS and GED	0.178*** (0.054) [0.072,0.284]	0.033*** (0.009) [0.014,0.052]	0.078*** (0.017) [0.045,0.110]	-0.002 (0.007) [-0.016,0.012]	0.062*** (0.015) [0.032,0.092]	0.043*** (0.007) [0.030,0.057]	0.039*** (0.007) [0.026,0.052]	0.033*** (0.006) [0.022,0.044]
College and above	0.301*** (0.057) [0.189,0.413]	0.114*** (0.010) [0.094,0.133]	0.177*** (0.017) [0.143,0.210]	0.121*** (0.008) [0.106,0.136]	0.143*** (0.016) [0.111,0.175]	0.172*** (0.007) [0.158,0.187]	0.125*** (0.007) [0.111,0.139]	0.060*** (0.006) [0.048,0.072]
Employment status								
Employed	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group
Not employed	0.048 (0.033) [-0.017,0.113]	0.013** (0.006) [0.000,0.025]	0.003 (0.010) [-0.017,0.022]	0.032*** (0.005) [0.023,0.041]	-0.006 (0.010) [-0.025,0.014]	-0.007* (0.004) [-0.015,0.001]	0.072*** (0.005) [0.062,0.083]	0.091*** (0.005) [0.082,0.100]
Poverty level								
Above poverty	0.058 (0.038) [-0.017,0.134]	-0.005 (0.010) [-0.024,0.014]	0.010 (0.015) [-0.020,0.039]	0.070*** (0.007) [0.055,0.085]	0.054*** (0.015) [0.025,0.083]	0.105*** (0.007) [0.091,0.118]	0.098*** (0.008) [0.083,0.113]	0.044*** (0.006) [0.032,0.056]
At or near poverty	-0.010 (0.043) [-0.095,0.075]	-0.016 (0.010) [-0.036,0.004]	0.008 (0.016) [-0.024,0.040]	0.007 (0.008) [-0.009,0.022]	0.023 (0.015) [-0.007,0.052]	0.025*** (0.007) [0.011,0.039]	0.002 (0.008) [-0.013,0.018]	0.016** (0.007) [0.003,0.030]
Below poverty	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group
Self-selected Health status								
Excellent	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group
Other	0.034 (0.031) [-0.026,0.095]	-0.013** (0.005) [-0.024,-0.003]	-0.001 (0.008) [-0.018,0.015]	-0.007* (0.004) [-0.015,0.001]	-0.013 (0.008) [-0.030,0.003]	0.003 (0.004) [-0.004,0.010]	-0.019*** (0.004) [-0.028,-0.011]	0.033*** (0.004) [0.025,0.041]
BMI status								
Normal and below weight	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group
Overweight	-0.029 (0.032) [-0.092,0.034]	-0.012** (0.006) [-0.023,-0.001]	0.003 (0.009) [-0.015,0.020]	0.009** (0.004) [0.001,0.017]	0.009 (0.009) [-0.010,0.027]	-0.001 (0.004) [-0.008,0.007]	0.004 (0.005) [-0.005,0.013]	0.003 (0.004) [-0.005,0.011]
Obese	-0.073** (0.032) [-0.136,-0.009]	-0.004 (0.006) [-0.016,0.008]	0.000 (0.009) [-0.018,0.018]	0.006 (0.005) [-0.003,0.016]	0.015 (0.009) [-0.003,0.033]	-0.005 (0.004) [-0.013,0.003]	0.001 (0.005) [-0.009,0.011]	0.018*** (0.004) [0.010,0.027]
Usual place for healthcare								
Yes	0.080** (0.033) [0.015,0.144]	0.030*** (0.009) [0.013,0.047]	0.046*** (0.012) [0.021,0.070]	0.173*** (0.007) [0.159,0.186]	0.120*** (0.014) [0.093,0.148]	0.060*** (0.006) [0.048,0.072]	0.150*** (0.009) [0.132,0.168]	0.136*** (0.008) [0.121,0.151]
No	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group
Health insurance								
Yes	0.174*** (0.042) [0.091,0.256]	0.056*** (0.009) [0.038,0.074]	0.092*** (0.014) [0.066,0.119]	0.173*** (0.008) [0.158,0.188]	0.087*** (0.015) [0.057,0.117]	0.096*** (0.007) [0.083,0.109]	0.188*** (0.011) [0.166,0.209]	0.110*** (0.011) [0.089,0.132]
No	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group
Asthma								
Yes	0.007 (0.035) [-0.062,0.076]	0.036*** (0.007) [0.022,0.050]	0.049*** (0.011) [0.029,0.070]	0.036*** (0.005) [0.026,0.045]	0.058*** (0.010) [0.038,0.078]	0.012*** (0.004) [0.003,0.021]	0.029*** (0.006) [0.017,0.041]	0.106*** (0.006) [0.094,0.118]
No	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group
Heart disease								

	HPV (19–26)	Hepatitis A (19+)	Hepatitis B (19–59)	Flu (19+)	Tetanus (Td) (19+)	COVID- 19 (19+)	Shingles (50+)	Pneumonia (50+)
	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)
Yes	—	-0.005 (0.011) [-0.026,0.017]	-0.022 (0.028) [-0.076,0.032]	0.065*** (0.007) [0.050,0.079]	0.021 (0.016) [-0.011,0.053]	0.009 (0.007) [-0.005,0.024]	0.004 (0.007) [-0.009,0.016]	0.059*** (0.006) [0.046,0.071]
No	—	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group
Diabetes								
Yes	0.123 (0.120) [-0.114,0.359]	0.012 (0.009) [-0.005,0.029]	0.037** (0.016) [0.006,0.069]	0.097*** (0.006) [0.086,0.109]	0.020 (0.012) [-0.004,0.043]	0.047*** (0.005) [0.037,0.057]	0.031*** (0.006) [0.020,0.043]	0.100*** (0.006) [0.088,0.113]
No	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group
Disability								
Yes	0.056 (0.058) [-0.057,0.169]	-0.004 (0.009) [-0.022,0.014]	0.017 (0.016) [-0.015,0.049]	0.010* (0.006) [-0.002,0.022]	0.001 (0.013) [-0.025,0.027]	-0.016*** (0.006) [-0.027,-0.005]	-0.026*** (0.006) [-0.037,-0.015]	0.027*** (0.006) [0.016,0.038]
No	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group
Travel								
Yes	—	0.107*** (0.005) [0.097,0.117]	0.100*** (0.008) [0.084,0.115]	—	—	—	—	—
No	—	Reference Group	Reference Group	—	—	—	—	—
Analytic Subpopulation N	1, 758	50, 378	24, 464	107, 598	23, 282	100, 822	61,481	60,892

Notes:

1. AMEs are average marginal effects from survey-weighted logistic regression models.
2. Standard errors are shown in parentheses and 95% confidence intervals in brackets.
3. Stars indicate statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
4. An em dash indicates that the variable was omitted from the vaccine-specific regression analysis.
5. Analyses are restricted to survey years in which each vaccination variable was available; therefore, sample sizes differ across the vaccines.
6. Sample sizes are unweighted and refer to the vaccine-specific analytic subpopulation used in the logistic regression model before estimating average marginal effects. Survey weights are used for all estimates.
7. Heart disease was excluded from the logistic regression model for HPV vaccination because no cases were observed.
8. Travel history is used as a control variable for Hepatitis A and B analysis due to its significant role in transmission

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The control variables in Table 4 show expected patterns. Education, health insurance, and having a usual place for care are generally positively associated with vaccination uptake. Other covariates, including age, gender, race/ethnicity, and health conditions, vary across vaccine outcomes. These estimates should be interpreted as conditional associations because they are adjusted for the full set of covariates included in the model.

4.3. Robustness and Sensitivity Analyses

I will include the 'Appendices' result explanation here in the final paper.

5. Discussion

I will include more discussion about findings, limitations and future directions of this study here, as well as concluding remarks for the final paper.

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Appendices

Appendix A1: Adjusted Linear Probability Model (LPM) of Vaccination Uptake by Sexual Orientation

	HPV (19-26)	Hepatitis A (19+)	Hepatitis B (19-59)	Flu (19+)	Tetanus (Td) (19+)	COVID-19 (19+)	Shingles (50+)	Pneumonia (50+)
	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)
Sexual Orientation								
Heterosexual	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group
Gay or Lesbian	0.039 (0.072) [-0.103,0.180]	0.114*** (0.019) [0.078,0.151]	0.168*** (0.023) [0.122,0.214]	0.095*** (0.013) [0.069,0.120]	0.038 (0.024) [-0.010,0.086]	0.113*** (0.009) [0.095,0.132]	0.139*** (0.018) [0.104,0.174]	0.093*** (0.017) [0.060,0.127]
Bisexual	0.186*** (0.042) [0.104,0.268]	0.092*** (0.018) [0.056,0.128]	0.045* (0.024) [-0.002,0.092]	0.035*** (0.012) [0.012,0.058]	0.030 (0.026) [-0.021,0.082]	0.113*** (0.011) [0.091,0.135]	0.048 (0.030) [-0.010,0.107]	-0.003 (0.031) [-0.064,0.058]
Analytic Subpopulation N	1, 758	50, 378	24, 464	107, 598	23, 282	100, 822	61, 481	60, 892

Appendix A2: Adjusted Logistic Regression Analysis of Vaccination Uptake by Combined Sexual Minority Group

	HPV (19-26)	Hepatitis A (19+)	Hepatitis B (19-59)	Flu (19+)	Tetanus (Td (19+)	COVID-19 (19+)	Shingles (50+)	Pneumonia (50+)
	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)
Sexual Orientation								
Heterosexual	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group
Sexual Minority	0.138*** (0.037) [0.065,0.212]	0.091*** (0.012) [0.067,0.115]	0.102*** (0.018) [0.068,0.137]	0.062*** (0.009) [0.045,0.079]	0.034* (0.018) [-0.002,0.070]	0.099*** (0.006) [0.087,0.112]	0.109*** (0.015) [0.081,0.138]	0.062*** (0.014) [0.035,0.089]
Analytic Subpopulation N	1, 758	50, 378	24, 464	107, 598	23, 282	100, 822	61, 481	60, 892

Appendix A3: Adjusted Logistic Regression Analysis of Vaccination Uptake with Survey Year Fixed Effects

	HPV (19-26)	Hepatitis A (19+)	Hepatitis B (19-59)	Flu (19+)	Tetanus (Td) (19+)	COVID-19 (19+)	Shingles (50+)	Pneumonia (50+)
	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)
Sexual Orientation								
Heterosexual	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group	Reference Group
Gay or Lesbian	--	0.105*** (0.018) [0.070,0.139]	0.164*** (0.023) [0.120,0.209]	0.092*** (0.012) [0.067,0.116]	--	0.111*** (0.009) [0.094,0.129]	0.131*** (0.017) [0.099,0.164]	0.083*** (0.015) [0.053,0.113]

	HPV (19-26)	Hepatitis A (19+)	Hepatitis B (19-59)	Flu (19+)	Tetanus (Td) (19+)	COVID-19 (19+)	Shingles (50+)	Pneumonia (50+)
	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)	AME SE (95% CI)
Bisexual	--	0.078*** (0.016) [0.046,0.110]	0.043* (0.023) [-0.003,0.089]	0.039*** (0.011) [0.017,0.061]	--	0.093*** (0.008) [0.076,0.109]	0.048* (0.028) [-0.007,0.104]	-0.003 (0.026) [-0.054,0.048]
Analytic Subpopulation N	–	50, 378	24, 464	107, 598	–	100, 822	61, 481	60, 892