

# Vaccination during pregnancy by race/ethnicity: a focus on American Indians/Alaska Natives



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**BACKGROUND:** Vaccination during pregnancy reduces the incidence of infections and their associated adverse outcomes in both mothers and infants. The American College of Obstetricians and Gynecologists has recommended influenza and Tdap vaccination during pregnancy since 2004 and 2013, respectively. Several studies have examined disparities in vaccination rates during pregnancy by race/ethnicity. However, none have included American Indians/Alaska Natives as a specific racial/ethnic group on a national level. Current literature suggests that American Indian/Alaska Native infants experience increased morbidity and mortality from both influenza and pertussis infections compared with most other groups in the United States.

**OBJECTIVE:** This study aimed to evaluate the uptake of influenza and Tdap vaccinations during pregnancy by race/ethnicity, with a specific focus on American Indian/Alaska Native people.

**STUDY DESIGN:** This cross-sectional study used data from the Pregnancy Risk Assessment Monitoring System. Comparisons of vaccine uptake across racial/ethnic groups (American Indian/Alaska Native, Asian, non-Hispanic Black, non-Hispanic White, Hispanic, and "None of the above") were evaluated using weighted logistic regression analyses to estimate prevalence odds ratios with 95% confidence intervals. Models were adjusted for maternal age, parity, maternal education, marital status, payment method at delivery, prenatal care in first trimester, maternal smoking status, Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) participation, and receipt of influenza vaccine reported by a health care provider.

**RESULTS:** For both vaccines, Asian respondents had the highest uptake (influenza, 70.1%; Tdap, 68.2%), whereas Black respondents reported the lowest uptake (influenza, 44.4%; Tdap, 57.9%). For the influenza vaccine, American Indian/Alaska Native respondents demonstrated a higher uptake compared with White respondents, and the magnitude of difference increased markedly after adjusting for respondent characteristics (adjusted odds ratio, 1.74; 95% confidence interval, 1.58–1.90). In the unadjusted analyses, Black individuals reported influenza vaccination at approximately half the rate of their White counterparts during pregnancy. This effect was attenuated but remained lower after adjustment for respondent characteristics (adjusted odds ratio, 0.73; 95% confidence interval, 0.70–0.76). For the Tdap vaccine, American Indian/Alaska Native respondents reported lower uptake than White respondents; however, this difference disappeared when adjusted for respondent characteristics (adjusted odds ratio, 0.99; 95% confidence interval, 0.83–1.19). Asian and Hispanic respondents displayed a similar uptake compared with their White counterparts for both vaccines.

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**CONCLUSION:** Our findings indicate that there are racial/ethnic disparities in influenza and Tdap vaccination rates among pregnant individuals in the United States. Demonstration of increased uptake among American Indian/Alaska Native people in the crude analysis may reflect the success of various public health interventions through Tribal and Indian Health Service hospitals. Nonetheless, vaccination status during pregnancy remains seriously below national guideline recommendations. Greater measures must be taken to support preventative care in marginalized populations, with particular emphasis on community-driven solutions rooted in justice.

**Key words:** American Indian/Alaska Native, ethnicity, influenza, pregnancy, Pregnancy Risk Assessment Monitoring System, race, Tdap, vaccination, vaccine-preventable infectious disease

## AJOG Global Reports at a Glance

### Why was this study conducted?

This study aimed to evaluate the uptake of influenza and Tdap vaccinations during pregnancy by race/ethnicity, with a specific focus on American Indian/Alaska Native (AIAN) people, who have been excluded from other national studies on this topic.

### Key findings

AIAN people are not vaccinated at lower rates than White people according to this national Pregnancy Risk Assessment Monitoring System data set.

### What does this add to what is known?

Despite carrying a disproportionate share of the morbidity and mortality of the vaccine-preventable diseases of influenza and pertussis, AIAN people are vaccinated at higher (influenza) or similar (Tdap) rates when using White survey respondents as a referent. Black individuals continue to receive vaccines at the lowest rates of all racial/ethnic groups studied, with a notable decline in uptake from 2016 to 2020.

## Introduction

Vaccination during pregnancy is a well-established intervention to lower the incidence of infection and associated morbidity and mortality among pregnant people and their neonates. Influenza infection during the antepartum or postpartum period is associated with more frequent medical visits, longer hospitalizations, and more intensive care unit (ICU) admissions compared with influenza infection in nonpregnant individuals, and is also associated with adverse neonatal outcomes.<sup>1</sup> Children aged <6 months are at greatest risk of morbidity and mortality from influenza infection, and are >4 times as likely to die of influenza infection than children aged 2 to 17 years.<sup>2</sup> This age group is also more likely to require hospitalization and experience complications ranging from pneumonia to sepsis. Current influenza vaccines are not approved for infants aged <6 months; thus, maternal vaccination and passive antibody

protection remains the best opportunity to protect infants.<sup>1</sup> The American College of Obstetricians and Gynecologists (ACOG) calls influenza immunization “an integral element of prepregnancy, prenatal, and postpartum care” and has recommended routine vaccination during any trimester since 2004.<sup>1</sup> A number of large-scale, randomized controlled trials have further demonstrated neonatal protection, including lower rates of influenza-associated hospitalization, in association with maternal influenza vaccination.<sup>1,3</sup>

In 2013, ACOG recommended that every pregnant person receive the tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis (Tdap) vaccine because of the dramatic protection offered to the fetus and neonate.<sup>4</sup> The beneficial effects of maternal Tdap vaccination have been reconfirmed by a number of studies in the interim.<sup>4,5</sup> In contrast to influenza, which can dramatically impact the health of both the

pregnant person and their infant, pertussis rarely results in hospitalization for adults aged <65 years. Pertussis vaccination in pregnancy is primarily intended for the protection of infants, who are at greatest risk of detrimental outcomes related to pertussis when aged <3 months.<sup>4</sup> Infants diagnosed with pertussis are more likely to experience a hospitalization (35% vs 3.3%) and visit the emergency department (47% vs 19%) compared with matched counterparts without a pertussis diagnosis.<sup>6</sup> However, infants whose mothers receive a Tdap vaccination at approximately 27 to 36 weeks of gestation have dramatically lower risks of hospitalization (50% lower), ICU admission (20% lower), and death (nearly 100% reduction).<sup>4,7</sup>

Approximately 9.7 million people (just under 3%) identified as American Indian/Alaska Native (AIAN) in the 2020 United States census. Although we recognize that AIAN people are ethnically diverse, with their own rich customs, traditions, and histories, as a group they have experienced similar health disparities, less access to prenatal care (PNC), and increased adverse outcomes relative to the general US population.<sup>8</sup> A number of studies indicate that AIAN infants are up to 5 times more likely to require hospitalization for pertussis and influenza than the average US infant,<sup>9–11</sup> with a 1.5 to 2 times greater overall age-adjusted death rate from influenza relative to the general population.<sup>2,11</sup> Along with this increase in infant morbidity and mortality, Native families and communities must devote disproportionately more time to caring for sick children. This results in reduced working hours and earned income, in addition to the added time and monetary expense of travel to

and from medical centers, all of which further exacerbate existing inequities.<sup>8,12</sup>

Most studies demonstrate an overall positive trend of increasing vaccination, with the largest rise in uptake coming the year after vaccination guidelines are updated.<sup>13,14</sup> Although the current literature reports racial/ethnic disparities in vaccine uptake during pregnancy,<sup>14–16</sup> none of these studies included AIAN as a distinct subgroup. In this study, we aimed to evaluate the uptake of influenza and Tdap vaccinations during pregnancy by race/ethnicity, with inclusion of AIAN people as a study group.

### Materials and Methods

This is a cross-sectional study using the Centers for Disease Control and Prevention's (CDC) Pregnancy Risk Assessment Monitoring System (PRAMS) Phase 7 and Phase 8 (2012–2020) survey data. PRAMS is an

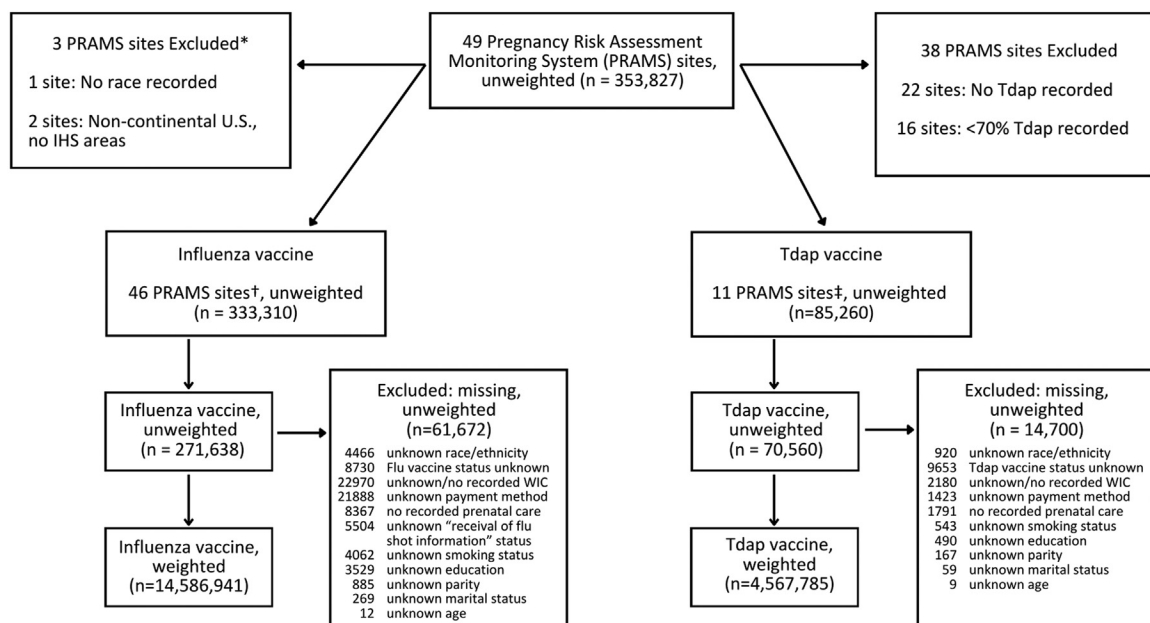
ongoing, population-based survey sent by each site (roughly each US state) to a stratified random sample of individuals approximately 2 months after delivery of a live-born infant to collect data on maternal behaviors.<sup>17</sup> All sites use the same “Core” survey questionnaire, but each site can select additional questions from a “Standard” list to further specialize the survey for local needs; further details can be found on the PRAMS website.<sup>17</sup> Data collected from the surveys were combined with information from birth certificates. The study protocol was reviewed by the University of Oklahoma Institutional Review Board and met the criteria for exemption because all study data were deidentified by the CDC before sharing.

Mother's race/ethnicity was obtained from birth certificate variables, which we categorized into AIAN, Asian, Black, Hispanic, White, and “None of the

above,” which included categories specified as “other non-White” or “mixed race.” We included influenza vaccination status, a component of the Core questionnaire, from all participating sites meeting the minimum response rate threshold required by PRAMS for data release (60%, 2012–2014; 55%, 2015–2017; 50%, 2018–2020),<sup>17</sup> covering 46 sites in the continental United States and Alaska (Figure 1). Hawaii and Puerto Rico were excluded because these sites are noncontinental and lack Indian Health Service (IHS) areas. We defined the “yes” group for influenza vaccination status as those participants who received an influenza vaccine during the 12 months before the delivery of the newborn (before or during pregnancy), and nonrecipients were placed in the “no” group.

There were 27 sites that assessed Tdap vaccination status, with response

**FIGURE 1**  
Flowchart of study participants



\*Vermont; Hawaii, Puerto Rico

† 46 sites included: Alaska, Alabama, Arkansas, Arizona, Colorado, Connecticut, District of Columbia, Delaware, Florida, Georgia, Iowa, Illinois, Indiana, Kansas, Kentucky, Louisiana, Massachusetts, Maryland, Maine, Michigan, Minnesota, Missouri, Mississippi, Montana, North Carolina, North Dakota, Nebraska, New Hampshire, New Jersey, New Mexico, New York, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Tennessee, Texas, Utah, Virginia, Washington, Wisconsin, West Virginia, Wyoming, and New York City.

‡ 11 sites included: Colorado, Delaware, Missouri, Mississippi, Montana, New York, Oklahoma, Pennsylvania, Texas, Virginia, Wisconsin

WIC, Special Supplemental Nutrition Program for Women, Infants, and Children.

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rates between 11.0% and 92.3%, as this was not part of the Core questionnaire. Given an apparent split of response rates <50% or >70% among sites with available Tdap information, for this analysis we selected the higher response threshold and included the 11 sites that had at least a 70% response rate (Figure 1). We defined the “yes” group for Tdap vaccination in pregnancy as those participants who responded, “Yes, I received Tdap during my pregnancy,” which best follows guidelines regarding the ideal time frame to confer placental antibodies to the full-term neonate.<sup>4</sup> Respondents who received the Tdap vaccine at any other period (responded “Yes, I received Tdap before my pregnancy” and/or “Yes, I received Tdap after my pregnancy”) were placed in the “no” group.

We summarized participant characteristics by calculating raw frequencies and weighted percentages, where the survey weights were applied to account for the complex sampling design and to generate national estimates. We compared participant characteristics by vaccination status using the Rao–Scott chi-square test. Comparisons of vaccination uptake across racial/ethnic groups (AIAN, Asian, Black, Hispanic, White, and None of the above) were evaluated using weighted logistic regression analyses to estimate prevalence odds ratios (ORs) with 95% confidence intervals (CIs). To evaluate racial/ethnic differences in vaccine uptake that would remain if characteristics were distributed equally across racial/ethnic groups, models were adjusted for maternal age; parity; mother’s education; marital status; insurance payment method; PNC in first trimester; maternal smoking status during pregnancy; Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) program participation; and reported receipt of influenza vaccination information from a health care provider. Furthermore, we stratified the analyses by US census regions (West, Midwest, South, and Northeast) and IHS areas. US census subregions were not used because of the risk of subdividing the AIAN sample size beyond statistical relevance. Models

were further adjusted for chronic conditions in a sensitivity analysis (pregnancy diabetes, hypertension, and depression). Patterns of vaccine uptake by race/ethnicity were examined over time (years 2012–2020), with linear trends evaluated by assessing interaction terms in the weighted logistic regression models for race/ethnicity and year measured as an ordinal variable. Statistical analyses were conducted using SAS 9.4 (SAS Institute Inc., Cary, NC).

Given that the recommended timing for maximum benefit of the Tdap vaccination is early in the 27- to 36-week window, we conducted a sensitivity analysis that restricted the Tdap uptake analysis to full-term deliveries. A subanalysis was also conducted using multinomial logistic regression to examine uptake of both vaccines, influenza alone, or Tdap alone relative to no vaccine uptake.

## Results

### Influenza vaccination

There were 271,638 individuals (weighted to represent 14,586,941 individuals) included in the influenza vaccination analysis. When comparing the characteristics of this influenza vaccine study sample with available data for excluded observations, participants had similar age distributions but were more likely to be White, exceed a high-school education, and have private insurance (Supplemental Table 1). The overall influenza vaccination rate was 58.4%. Most of the influenza vaccine recipients were aged between 30 and 34 years (64.9%), had  $\geq 16$  years of education (71.5%), reported receiving influenza vaccine information from a health provider (66.5%), started PNC in the first trimester (60.6%), and had private insurance (66.7%). Individuals covered by IHS were more likely to receive the influenza vaccine (60.4%) than not. Self-pay patients were the least likely to be vaccinated (40.0%). Asian respondents had the highest uptake (70.1%), whereas Black individuals reported the lowest uptake (44.4%) among the racial/ethnic groups. Of all respondents, 83.8% recalled receiving vaccine information from their health care provider

and 66.5% of this group received the influenza vaccination. However, 16.2% of all respondents did not recall receiving vaccine information and only 16.8% of this group reported receiving the vaccine (Table 1).

In unadjusted analyses, AIAN (OR, 1.17; 95% CI, 1.08–1.27) and Asian respondents (OR, 1.54; 95% CI, 1.45–1.64) displayed a higher uptake compared with White respondents. Black respondents were vaccinated at approximately half the frequency of their White counterparts (OR, 0.53; 95% CI, 0.51–0.54), whereas uptake for Hispanic and White respondents did not differ (OR, 1.00; 95% CI, 0.96–1.04). After adjustment for participant characteristics, the difference in uptake increased markedly for AIAN respondents (adjusted OR [aOR], 1.74; 95% CI, 1.58–1.90). The adjusted result was attenuated for Black respondents but remained lower than that of White respondents (aOR, 0.73; 95% CI, 0.70–0.76). The magnitude of increased uptake observed for Asian respondents remained similar after covariate adjustment, but Hispanic respondents displayed a higher uptake compared with their White counterparts in the adjusted analysis (Table 2). The results were essentially unchanged after adjusting for chronic disease conditions (Supplemental Table 2).

There were regional differences in vaccination coverage across the racial/ethnic groups. In the West, AIAN respondents had an appreciably greater uptake of influenza vaccination than White respondents (OR, 1.43; 95% CI, 1.32–1.56), which persisted after adjusting for covariates (aOR, 2.13; 95% CI, 1.91–2.37). AIAN respondents in the Northeast had a similar vaccination rate compared with White respondents (OR, 0.77; 95% CI, 0.35–1.70). Black respondents demonstrated a slightly higher vaccination rate than White respondents in the West, but had consistently lower vaccination uptake than White counterparts in the Midwest, South, and Northeast (Table 2).

AIAN respondents had greater vaccination uptake than their White counterparts across IHS areas except in the

Nashville area (Supplemental Table 3). From 2012 to 2020, influenza vaccination coverage was lowest among Black individuals and peaked at approximately 50% in 2016; uptake in this population has since regressed to levels close to those of 2012 (39%). Relative to vaccine uptake among White respondents, influenza vaccination increased over this time period among Hispanic ( $P<.0001$ ) and Asian respondents ( $P<.0001$ ) (Figure 2), but declined among Black respondents ( $P<.0001$ ) and remained similar among AIAN respondents ( $P=.25$ ).

### Tdap vaccination

There were 70,560 individuals (weighted to represent 4,567,785 individuals) included in the Tdap vaccination analysis. When comparing the characteristics of this Tdap vaccine study sample with available data for excluded observations, participants had similar distributions of age and education, but were more likely to be White and have private insurance (Supplemental Table 4). Overall, Tdap vaccination coverage was 62.0%. Most of the respondents who received Tdap vaccine were aged between 30 and 34 years (65.4%) and had  $\geq 16$  years of education (68.8%). Only 36.5% of respondents who reported self-payment received the Tdap vaccine, whereas all other payment methods reported uptake  $>50\%$ . As observed for influenza vaccination, Asian individuals reported the highest uptake (68.2%), whereas Black respondents reported the lowest uptake (57.9%) among the racial/ethnic groups (Table 3).

In unadjusted analyses, AIAN respondents showed a mildly lower uptake than White respondents (OR, 0.83; 95% CI, 0.70–0.98), and uptake was similarly reduced for Black (OR, 0.80; 95% CI, 0.75–0.87) and Hispanic (OR, 0.87; 95% CI, 0.80–0.94) respondents. In contrast, Tdap vaccine uptake was modestly greater in Asian respondents (OR, 1.25; 95% CI, 1.09–1.44) compared with the White reference group. When adjusted for respondent characteristics, differences observed for AIAN and Black respondents were

**TABLE 1**

**Characteristics of participants by influenza vaccination status, Pregnancy Risk Assessment Monitoring System, (PRAMS), 2012–2020 (n=271,638)**

Variable	Yes n (weighted %)	No n (weighted %)	P value <sup>a</sup>
<b>Race/ethnicity<sup>b</sup></b>			
AIAN	7020 (64.0)	3711 (36.0)	
Asian	12,383 (70.1)	4182 (29.9)	
Black	23,963 (44.4)	25,381 (55.6)	<.001
Hispanic	28,211 (60.3)	15,759 (39.7)	
White	85,389 (60.3)	52,001 (39.7)	
None of the above	8184 (56.4)	5454 (43.6)	
<b>Age (y)</b>			
$\leq 29$	82,773 (53.1)	64,405 (46.9)	
30–34	51,771 (64.9)	26,409 (35.1)	<.001
35–39	25,247 (64.9)	12,604 (35.1)	
$\geq 40$	5359 (60.9)	3070 (39.1)	
<b>Education (y)</b>			
<12	18,917 (50.7)	15,241 (49.3)	
12	34,068 (48.8)	31,358 (51.2)	<.001
13–15	45,133 (53.2)	35,167 (46.8)	
$\geq 16$	67,032 (71.5)	24,722 (28.5)	
<b>WIC during pregnancy</b>			
Yes	58,233 (51.0)	47,957 (49.0)	<.001
No	106,917 (62.7)	58,531 (37.3)	
<b>Smoking</b>			
Yes	12,601 (45.8)	13,422 (54.2)	<.001
No	152,549 (59.6)	93,066 (40.4)	
<b>Marital status</b>			
Married	107,982 (63.8)	55,298 (36.2)	<.001
Other	57,168 (49.6)	51,190 (50.4)	
<b>Parity</b>			
Nulliparous	66,375 (60.2)	40,534 (39.8)	<.001
Parous	98,775 (57.3)	65,954 (42.7)	
<b>Method of payment</b>			
Medicaid	60,667 (48.5)	55,435 (51.5)	
Private insurance	93,577 (66.7)	42,753 (33.3)	
Self-pay	3558 (40.0)	4134 (60.0)	<.001
Indian Health Service	708 (60.4)	426 (39.6)	
Government/Other	6640 (60.0)	3740 (40.0)	
<b>Influenza vaccine information from HCP</b>			
Yes	157,201 (66.5)	72,956 (33.5)	<.001
No	7949 (16.8)	33,532 (83.2)	

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(continued)

**TABLE 1**  
**Characteristics of participants by influenza vaccination status, Pregnancy Risk Assessment Monitoring System, (PRAMS), 2012–2020 (n=271,638)**

(continued)

Variable	Yes n (weighted %)	No n (weighted %)	P value <sup>a</sup>
Initiated PNC in first trimester			
Yes	146,425 (60.6)	86,834 (39.4)	<.001
No	17,789 (45.6)	18,229 (54.4)	
Unknown	936 (34.4)	1425 (65.6)	

AIAN, American Indian/Alaska Native; HCP, health care personnel; PNC, prenatal care; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children.

<sup>a</sup> Rao–Scott chi-square test; <sup>b</sup> Non-Hispanic: AIAN, White, Black, Asian, and other.

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attenuated, with ORs near the null value. Although the weak positive association for Asian respondents was largely unchanged following covariate adjustment, Hispanic respondents displayed a small increased uptake compared with their White counterparts (Table 4). Results were essentially unchanged when analyses were restricted to full-term deliveries (Supplemental Table 5) or after adjustment for chronic disease conditions (Supplemental Table 6).

AIAN respondents had a higher rate of Tdap vaccination than White respondents in the West region, but demonstrated a lower uptake than White respondents in the Midwest, South, and Northeast (Table 4). Across IHS areas, AIAN respondents had similar Tdap vaccination coverage as White respondents, except in the Nashville area, where they had a lower uptake (Supplemental Table 7). Tdap vaccination has increased among all racial/ethnic groups since 2012. However, there was a slight reduction in vaccine uptake among AIAN and Black respondents after 2019 (Figure 3). Relative to vaccine uptake among White respondents, racial/ethnic differences in Tdap vaccination patterns remained similar over this time period for AIAN ( $P=.52$ ) and Hispanic respondents ( $P=.47$ ), whereas uptake was increasingly greater for Asian respondents ( $P=.003$ ) but declined for Black respondents ( $P<.0001$ ).

### Both influenza and Tdap vaccination

In the sample of 69,589 participants with both influenza and Tdap vaccine measures available, patterns of uptake relative to no vaccine uptake were similar to those reported above for influenza vaccines, albeit attenuated (Supplemental Table 8). In unadjusted analyses, Black respondents received both vaccines at a lower frequency compared with White respondents (OR, 0.65; 95% CI, 0.59–0.71), whereas uptake of both vaccines was higher among Asian participants (OR, 1.42; 95% CI, 1.18–1.70) and similar to that of White participants among AIAN and Hispanic respondents. After adjustment for participant characteristics, the difference in uptake increased modestly for Asian (aOR, 1.24; 95% CI, 1.02–1.49) and AIAN respondents (aOR, 1.34; 95% CI, 1.06–1.71) and more markedly for Hispanic respondents (aOR, 1.61; 95% CI, 1.41–1.82). The adjusted result was attenuated for Black respondents, but remained lower than that of White respondents (aOR, 0.90; 95% CI, 0.81–1.01).

Uptake of influenza vaccination alone remained lower among Black respondents compared with their White counterparts in unadjusted comparisons, with AIAN, Asian, and Hispanic groups displaying slightly higher uptake. These differences were no longer observed for Black and Asian respondents after controlling for participant characteristics, but uptake increased further for AIAN

and Hispanic respondents when holding covariates constant. For Tdap uptake alone, no differences were observed by race/ethnicity in unadjusted analyses. Upon controlling for covariates, slight increases in Tdap uptake were noted among Asian and Hispanic respondents.

### Comment Principal findings

Our study found that influenza and Tdap vaccination uptake during pregnancy continues to display differences by racial and ethnic identity in the United States, with AIAN people having slightly greater uptake of the influenza vaccine but reduced uptake of Tdap.

### Results

The trends found in our study are similar to those discovered in other published analyses of PRAMS data, with Asian individuals having the highest rate of vaccination and Black people the lowest.<sup>14,15</sup> Across multiple studies, respondents were more likely to receive both influenza and Tdap vaccines during pregnancy if they were privately insured (vs Medicaid), the vaccine was free, the respondent was married, received >16 years of education, had received information about the influenza vaccine from a health care provider, or had accessed PNC in the first trimester.<sup>18–22</sup> The greatest racial/ethnic difference between studies pertains to the Hispanic population surveyed. Namely, some studies found this group to have the second-lowest uptake, falling between Black and White respondents for the Tdap vaccine only.<sup>20,21</sup> Other studies reported uptake just higher than that of White respondents,<sup>15,16,22</sup> whereas some reported no discernible difference from their White counterparts for the influenza vaccine only.<sup>21</sup> This likely reflects the sociocultural differences within this ethnic group, which encompasses multiple countries of origin. Indeed, the complex and unique interactions among immigrant communities and their intersection with health care are not adequately captured by a single ethnic label.<sup>23</sup>

**TABLE 2**

**Crude and adjusted analysis of influenza vaccination (12 months before delivery of infant, N=271,638) with additional breakdown according to US region, Pregnancy Risk Assessment Monitoring System (PRAMS), 2012–2020**

Race/ethnicity	Crude OR (95% CI)	Adjusted OR <sup>a</sup> (95% CI)
AIAN (n=10,731)	1.17 (1.08–1.27)	1.74 (1.58–1.90)
Asian (n=16,565)	1.54 (1.45–1.64)	1.46 (1.36–1.56)
Black (n=49,344)	0.53 (0.51–0.54)	0.73 (0.70–0.76)
Hispanic (n=43,970)	1.00 (0.96–1.04)	1.53 (1.46–1.61)
White (n=137,390)	Referent	Referent
None of the above (n=13,638)	0.85 (0.80–0.91)	1.05 (0.97–1.13)
US region		
West (n=63,070)		
AIAN (n=5787)	1.43 (1.32–1.56)	2.13 (1.91–2.37)
Asian (n=4353)	1.92 (1.73–2.12)	1.80 (1.61–2.02)
Black (n=2687)	1.07 (0.94–1.22)	1.31 (1.14–1.50)
Hispanic (n=14,098)	1.20 (1.13–1.27)	1.67 (1.55–1.80)
White (n=31,641)	Referent	Referent
None of the above (n=4504)	1.01 (0.90–1.14)	1.14 (1.00–1.30)
Midwest (n=82,136)		
AIAN (n=3242)	1.04 (0.89–1.22)	1.65 (1.37–2.00)
Asian (n=4529)	1.51 (1.36–1.68)	1.49 (1.33–1.66)
Black (n=19,046)	0.49 (0.47–0.52)	0.72 (0.67–0.77)
Hispanic (n=11,080)	0.97 (0.91–1.04)	1.47 (1.36–1.60)
White (n=39,767)	Referent	Referent
None of the above (n=4472)	0.82 (0.73–0.91)	1.07 (0.95–1.20)
South (n=75,708)		
AIAN (n=1588)	1.01 (0.84–1.21)	1.32 (1.09–1.61)
Asian (n=2314)	1.31 (1.14–1.51)	1.16 (0.99–1.36)
Black (n=20,639)	0.54 (0.51–0.57)	0.70 (0.65–0.75)
Hispanic (n=9876)	1.00 (0.93–1.08)	1.47 (1.33–1.62)
White (n=38,506)	Referent	Referent
None of the above (n=2785)	0.80 (0.70–0.92)	0.93 (0.79–1.09)
Northeast (n=50,724)		
AIAN (n=114)	0.77 (0.35–1.70)	1.07 (0.49–2.35)
Asian (n=5369)	1.61 (1.45–1.78)	1.57 (1.40–1.75)
Black (n=6972)	0.68 (0.62–0.74)	0.94 (0.84–1.04)
Hispanic (n=8916)	0.97 (0.90–1.05)	1.50 (1.36–1.65)
White (n=27,476)	Referent	Referent
None of the above (n=1877)	0.84 (0.72–0.99)	1.09 (0.90–1.31)

AIAN, American Indian/Alaska Native; CI, confidence interval; OR, odds ratio.

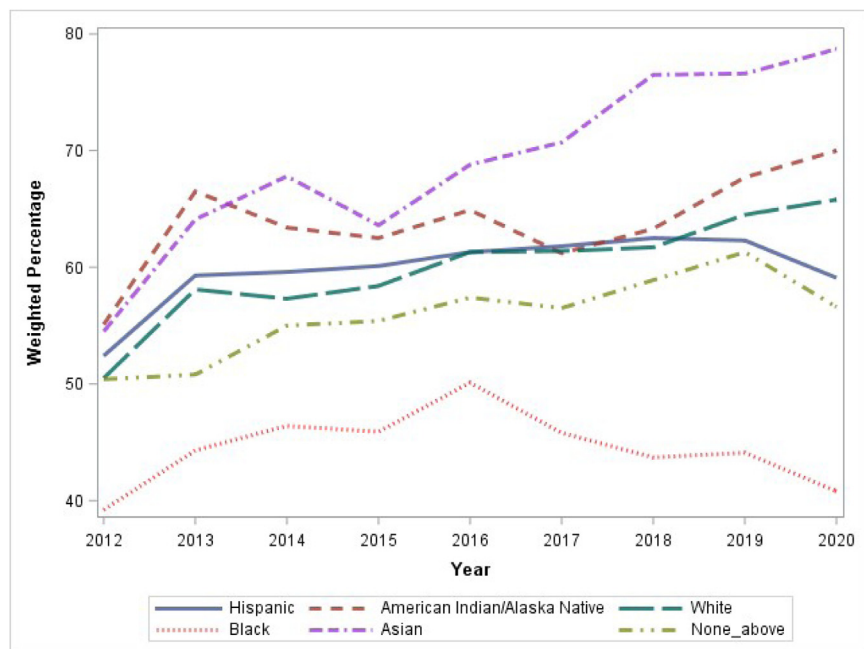
<sup>a</sup> Adjusted for maternal age, mother's education, marital status, parity, insurance payment method, influenza shot information, prenatal care in first trimester, maternal smoking status, and Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) participation.

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Our adjusted results indicate the extent of racial/ethnic disparities in vaccine uptake that would remain if the distributions of socioeconomic and other potentially explanatory characteristics were equalized across racial/ethnic groups. It is expected that differences in vaccine uptake would further improve when balancing demographic and socioeconomic conditions across groups. Although this anticipated improvement was observed for most racial/ethnic groups for both influenza and Tdap vaccine uptake, it is notable that adjusted influenza vaccine uptake remained lower for Black respondents compared with the White reference group after accounting for suspected correlates and mediating factors. This suggests that remaining differences may be attributed to cultural context, discrimination, and/or other unmeasured factors that warrant further investigation to identify and reduce barriers to influenza vaccination uptake in this population.

Most substantially, this analysis expands upon the few regional studies inclusive of AIAN people. When separated by region, AIAN people in the Midwest displayed no difference in crude or adjusted Tdap uptake compared with White respondents and had the highest adjusted uptake of influenza vaccination in the same region. A 2017 study in Minnesota identified AIAN pregnant individuals (n=2174; 1.9%) as having the lowest uptake for Tdap and second lowest for influenza, but this study only shared the unadjusted risk ratio.<sup>20</sup> Our results revealed modest differences compared with the White reference group, with AIAN respondents experiencing slightly higher influenza vaccine uptake but also slightly lower Tdap vaccine uptake. The effect size became larger and continued to exclude the null value in the adjusted analysis of influenza vaccine uptake for AIAN people, indicating higher uptake for this group when other respondent characteristics are held constant and possibly highlighting the success of IHS facilities in providing care. Another study from Michigan did not find a statistically significant difference in Tdap uptake

**FIGURE 2**  
Influenza vaccination by race/ethnicity



The proportion of influenza vaccine recipients from 2012 to 2020 is displayed.

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during pregnancy between AIAN people and their referent.<sup>24</sup>

### Clinical implications

Reasons for vaccine hesitancy are well researched, especially in light of the COVID-19 pandemic, but we must first center the experiences and voices of marginalized communities who have historically faced and continue to experience mistreatment in the medical system. Black patients in particular have experienced well-documented historical injustices.<sup>25</sup> Despite this, several studies indicate that most medically underserved patients continue to view their physicians as the most trusted source of information and report physician recommendation as the most important reason for receiving the vaccine.<sup>23,26,27</sup> One prominent barrier to vaccination uptake is a lack of knowledge regarding the benefits of vaccination during pregnancy.<sup>1,15</sup> Our analysis indicates that approximately two-thirds of patients will ultimately receive a vaccine following their health care provider's recommendation, whereas only 16.8%

of those without a recommendation underwent vaccination, very closely reflecting the findings of Ding et al.<sup>16</sup> This analysis reemphasizes the importance of the patient–provider relationship and the role of provider bias in preventative medicine, particularly as a 2019 study of the PRAMS database identified a correlation between patient race/ethnicity and provider recommendation for vaccination.<sup>15</sup> Overall, acceptance of Tdap is higher among pregnant than nonpregnant people. A survey conducted by Dempsey et al<sup>28</sup> indicated that pregnant individuals are most concerned about the safety and effectiveness of the vaccine for their neonate, with these concerns being greatest among nonnative English speakers. Vaccination rates for both vaccines have decreased slightly since the start of the COVID-19 pandemic, and vaccine hesitancy associated with COVID-19 is its own complex issue.<sup>29,30</sup> Moreover, many patients have delayed preventative care, which impacts access to early PNC services. Before the pandemic, 13.1% of AIAN individuals received late

or no PNC as opposed to 4.5% of non-Hispanic White individuals.<sup>8</sup> Interventions involving regular home visits from a trained medical professional have shown better psychiatric and developmental outcomes for mothers and infants in the postpartum period; however, evaluation of program impact on earlier PNC access remains ongoing.<sup>8</sup> Robust, interprofessional, and community-based programs may offer promise for improving vaccination uptake, but further data-driven research is warranted.

Notably, only 13% of AIAN people live on federally recognized reservations, and only 60% live in metropolitan areas (the lowest percentage of any minority group).<sup>31</sup> It is likely that the IHS has played a critical role in the vaccination rate of this population, although IHS clinics only serve approximately 25% of its target population and regularly receive inadequate funding despite the agreements in federal treaties.<sup>32,33</sup> Policy solutions to improve vaccination uptake must include funding for essential health care infrastructure.

### Research implications

The AIAN population is vaccinated at a higher rate than White respondents—a trend that may have begun as early as 2005<sup>10</sup>—yet this population continues to carry a much higher percentage of morbidity and mortality from vaccine-preventable diseases.<sup>2,10,32</sup> This disparity is alarming and warrants further investigation. Historically, the *Haemophilus influenzae* type B (Hib) vaccine was found to be less immunogenic in AIAN infants compared with the general US population in the 1980s, spawning an investigation of a number of other vaccines at that time.<sup>32</sup> The Hib vaccine remains the only example of this reduced efficacy to date, but more studies may be warranted.<sup>34</sup> Follow-up studies are needed to further investigate the limitations of vaccination as a chief preventative tool in this population.

### Strengths and limitations

The strengths of our study include the use of the national PRAMS database,



**TABLE 3**  
**Characteristics of participants by Tdap vaccination status, Pregnancy Risk Assessment Monitoring System (PRAMS), 2012–2020 (n=70,560)**

Variable	Yes n (weighted %)	Non (weighted %)	P value <sup>a</sup>
<b>Race/ethnicity<sup>b</sup></b>			
AIAN	1434 (58.5)	807 (41.5)	
Asian	1795 (68.2)	860 (31.8)	
Black	6861 (57.9)	5902 (42.1)	<.001
Hispanic	5709 (59.7)	3695 (40.3)	
White	24,322 (63.1)	15,621 (36.9)	
None of the above	2147 (60.6)	1407 (39.4)	
<b>Age (y)</b>			
≤29	22,088 (60.2)	16,261 (39.8)	
30–34	13,017 (65.4)	7469 (34.6)	<.001
35–39	6000 (63.3)	3643 (36.7)	
≥40	1163 (56.1)	919 (43.9)	
<b>Education (y)</b>			
<12	4077 (50.6)	4118 (49.4)	
12	9380 (59.3)	7221 (40.7)	<.001
13–15	12,219 (59.9)	8934 (40.1)	
≥16	16,592 (68.8)	8019 (31.2)	
<b>WIC during pregnancy</b>			
Yes	14,484 (57.8)	11,686 (42.2)	<.001
No	27,784 (64.3)	16,606 (35.7)	
<b>Smoking</b>			
Yes	3757 (57.3)	3244 (42.7)	<.001
No	38,511 (62.5)	25,048 (37.5)	
<b>Marital status</b>			
Married	26,753 (63.2)	16,448 (36.8)	<.001
Other	15,515 (60.0)	11,844 (40.0)	
<b>Parity</b>			
Nulliparous	18,307 (66.8)	10,398 (33.2)	<.001
Parous	23,961 (58.8)	17,894 (41.2)	
<b>Method of payment</b>			
Medicaid	16,042 (57.3)	13,344 (42.7)	
Private insurance	23,803 (67.0)	12,487 (33.0)	
Self-pay	719 (36.5)	1252 (63.5)	<.001
Indian Health Service	112 (56.3)	63 (43.7)	
Government/Other	1592 (62.0)	1146 (38.0)	
<b>Initiated PNC in first trimester</b>			
Yes	37,259 (64.2)	23,240 (35.8)	
No	4831 (50.0)	4662 (50.0)	<.001
Unknown	178 (35.1)	390 (64.9)	

AIAN, American Indian/Alaska Native; HCP, health care personnel; PNC, prenatal care; WIC, Special Supplemental Nutrition Program for Women, Infants, and Children.

<sup>a</sup> Rao–Scott chi-square test; <sup>b</sup> Non-Hispanic: AIAN, White, Black, Asian, and other.

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which enabled the assessment of a very large and representative sample of the US population. Standardization of the data collection process allowed comparison between sites and achieved site response rates >60% over many years. These factors all contribute to the generalizability of the study results. In addition, the self-reporting of racial/ethnic data by respondents via birth certificates provided a more accurate representation of AIAN people relative to studies that rely on third-party classification in medical records or methods that prioritize a Hispanic classification over other reported racial/ethnic categories.

Our study has limitations, many of which are secondary to the inherent limitations of the PRAMS survey itself. Selection bias is a risk with any survey data, and individuals who are more likely to complete a health-related questionnaire may also be more likely to have been vaccinated. This concern may be even more relevant for recent PRAMS data given that the minimum threshold response rate for data release has decreased from 65% in 2011 to 50% in 2020.<sup>17</sup> Among PRAMS respondents, exclusions from the analytical sample due to missing data may have impacted measures of health disparities by restricting representation of racial/ethnic minorities and people of lower socioeconomic status. Furthermore, the survey is sent several months after delivery and may be impacted by poor recall (eg, being unable to recall a conversation with a health care provider). The survey is also limited to live births; thus, the observed patterns of vaccine uptake may be impacted by this selection factor, and generalizability is limited to pregnancies resulting in live deliveries. In addition, although national guidelines advise administration of the Tdap vaccine as early in the recommended window (27–36 weeks' gestation) as possible to achieve maximum benefit,<sup>4</sup> individuals who delivered preterm would have had fewer opportunities to receive the vaccine. However, our observed results remained consistent in sensitivity analyses that restricted the assessment to full-term

**TABLE 4****Crude and adjusted analysis of Tdap vaccination (during pregnancy, N=70,560), with additional breakdown according to US region, Pregnancy Risk Assessment Monitoring System (PRAMS), 2012–2020**

Race/ethnicity	Crude OR (95% CI)	Adjusted OR <sup>a</sup> (95% CI)
AIAN (n=2241)	0.83 (0.70–0.98)	0.99 (0.83–1.19)
Asian (n=2655)	1.25 (1.09–1.44)	1.19 (1.04–1.37)
Black (n=12,763)	0.80 (0.75–0.87)	0.94 (0.86–1.02)
Hispanic (n=9404)	0.87 (0.80–0.94)	1.15 (1.05–1.27)
White (n=39,943)	Referent	Referent
None of the above (n=3554)	0.90 (0.79–1.03)	0.98 (0.86–1.13)
US region		
West (n=11,650)		
AIAN (n=558)	1.21 (0.89–1.64)	1.69 (1.23–2.32)
Asian (n=291)	0.96 (0.70–1.32)	0.93 (0.67–1.28)
Black (n=231)	0.83 (0.58–1.18)	0.98 (0.69–1.39)
Hispanic (n=2032)	0.96 (0.84–1.10)	1.17 (1.00–1.36)
White (n=8145)	Referent	Referent
None of the above (n=393)	1.04 (0.76–1.42)	1.12 (0.81–1.55)
Midwest (n=18,282)		
AIAN (n=316)	0.74 (0.51–1.07)	0.85 (0.58–1.24)
Asian (n=893)	1.34 (1.13–1.59)	1.31 (1.10–1.56)
Black (n=4977)	0.83 (0.75–0.92)	0.91 (0.81–1.04)
Hispanic (n=1672)	1.02 (0.90–1.16)	1.23 (1.07–1.42)
White (n=9131)	Referent	Referent
None of the above (n=1293)	0.96 (0.79–1.15)	1.01 (0.83–1.22)
South (n=27,425)		
AIAN (n=1354)	0.78 (0.63–0.97)	0.94 (0.74–1.18)
Asian (n=872)	1.35 (1.03–1.77)	1.24 (0.94–1.64)
Black (n=5979)	0.80 (0.71–0.91)	0.97 (0.84–1.12)
Hispanic (n=4373)	0.77 (0.67–0.89)	0.99 (0.85–1.16)
White (n=13,369)	Referent	Referent
None of the above (n=1478)	0.92 (0.72–1.17)	1.03 (0.81–1.30)
Northeast (n=13,203)		
AIAN (n=13)	0.68 (0.14–3.24)	0.83 (0.18–3.98)
Asian (n=599)	1.20 (0.96–1.49)	1.11 (0.89–1.40)
Black (n=1576)	0.81 (0.70–0.94)	0.88 (0.75–1.04)
Hispanic (n=1327)	1.00 (0.86–1.17)	1.18 (0.99–1.41)
White (n=9298)	Referent	Referent
None of the above (n=390)	0.81 (0.62–1.07)	0.84 (0.63–1.12)

AIAN, American Indian/Alaska Native; CI, confidence interval; OR, odds ratio.

<sup>a</sup> Adjusted for maternal age, mother's education, marital status, parity, insurance payment method, prenatal care in first trimester, maternal smoking status, and Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) participation. Jarshaw. Vaccination in pregnancy by race/ethnicity. *Am J Obstet Gynecol Glob Rep* 2024.

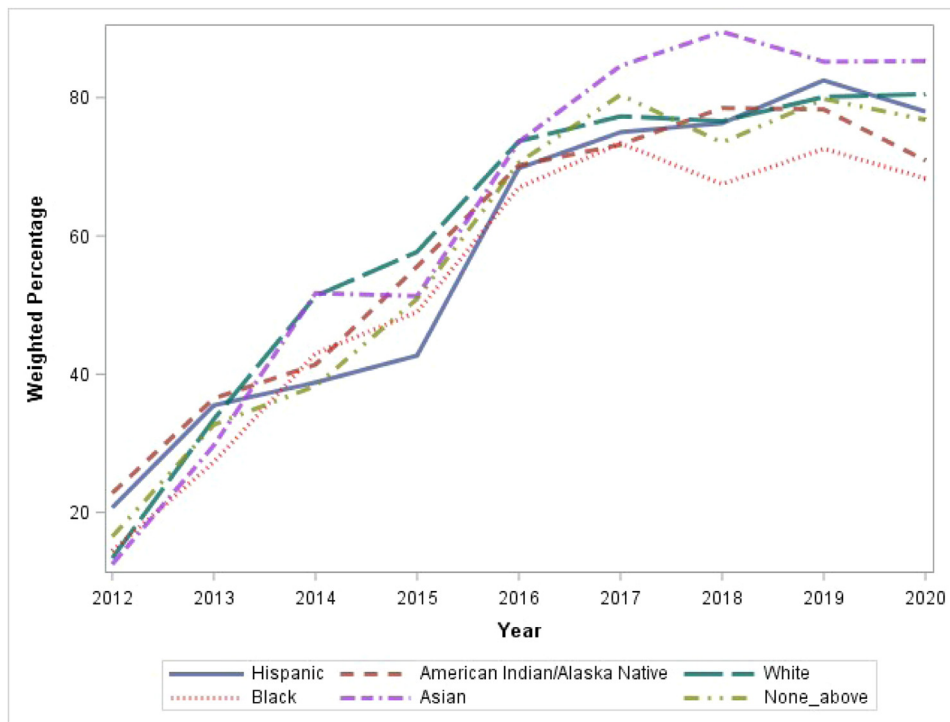
deliveries. In addition, the PRAMS data currently stops in 2020, mostly limiting our scope to the period before COVID-19 transformed health systems and health care utilization in the United States.

Finally, there are inherent limitations to studying race/ethnicity. Although race is a social construct rather than a biological fact, health care is not received in a vacuum, and social constructs hold real meaning. These data, presented along racial/ethnic lines, showcase real gaps in preventative medicine resulting from generations of systemic oppression and an often intentional dearth of resource allocation.<sup>25</sup> Individuals who identify as, or are identified by others as, members of the same minority racial/ethnic group often live in the same zip codes because of redlining, face similar policy rejections, and experience the cumulative impact of racism over generations, which takes a toll on their health.<sup>25</sup> As an extension of this limitation, PRAMS does not ask for specific tribal affiliation (except for Wyoming and North Dakota). However, each tribe is unique, and we recognize that classifying AIAN respondents into 1 study group is inherently problematic. The United States currently recognizes 574 tribes, which embody a rich cultural and ethnic diversity.<sup>35</sup> Although PRAMS sites are organized by state, this created limitations when evaluating the data by IHS region because certain tribes such as the Navajo span >1 state.

## Conclusions

In this national study evaluating the uptake of vaccines during pregnancy among AIAN people, this population was found to be more likely to receive the influenza vaccine but marginally less likely to receive Tdap compared with White respondents. It is possible that this denotes a major success of IHS care and efforts within Tribes. However, the disproportionate disease burden that persists among AIAN people despite the relatively high vaccination rates in this group raises more questions. Regional health systems need to

**FIGURE 3**  
Tdap vaccination by race/ethnicity



The proportion of Tdap vaccine recipients from 2012 to 2020 is displayed.

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create stronger partnerships with local tribes and Black communities, including in policy creation and the cultivation of adequate resources after centuries of abuse and mistrust.<sup>8</sup> Furthermore, future projects should center collaboration within communities to allow evaluation of the unique regional and cultural factors that drive individual and community behaviors, which could not be assessed by this nationwide study. Such a strategy necessitates better public funding and awareness of this crucial component of maternal and prenatal health, which has only been exacerbated by the COVID-19 pandemic.<sup>30</sup> Providers should advocate for patient and community awareness at all levels. ■

### CRediT authorship contribution statement

**Christen L. Jarshaw:** Conceptualization, Methodology, Project administration, Writing – original draft, Writing – review & editing. **Jennifer D. Peck:**

Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Writing – review & editing. **Stephanie Pierce:** Supervision, Writing – review & editing. **Emily J. Jones:** Resources, Supervision, Validation, Writing – review & editing, Resources, Supervision, Validation, Writing – review & editing. **Pardis Hosseinzadeh:** Conceptualization, Data curation, Methodology, Writing – review & editing. **LaTasha B. Craig:** Conceptualization, Data curation, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing.

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### Supplementary materials

Supplementary material associated with this article can be found in the online version at [doi:10.1016/j.xagr.2024.100318](https://doi.org/10.1016/j.xagr.2024.100318).

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