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RESEARCH ARTICLE

Study of selected birth defects among American Indian/Alaska Native population: A multi-state population-based retrospective study, 1999–2007

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Background: Higher prevalence of selected birth defects has been reported among American Indian/Alaska Native (AI/AN) newborns. We examine whether known risk factors for birth defects explain the higher prevalence observed for selected birth defects among this population.

Methods: Data from 12 population-based birth defects surveillance systems, covering a birth population of 11 million from 1999 to 2007, were used to examine prevalence of birth defects that have previously been reported to have elevated prevalence among AI/ANs. Prevalence ratios (PRs) were calculated for non-Hispanic AI/ANs and any AI/ANs (regardless of Hispanic ethnicity), adjusting for maternal age, education, diabetes, and smoking, as well as type of case-finding ascertainment surveillance system.

Results: After adjustment, the birth prevalence of two of seven birth defects remained significantly elevated among AI/ANs compared to non-Hispanic whites (NHWs): anotia/microtia was almost threefold higher, and cleft lip +/− cleft palate was almost 70% higher compared to NHWs. Excluding AI/AN subjects who were also Hispanic had only a negligible impact on adjusted PRs.

Conclusions: Additional covariates accounted for some of the elevated birth defect prevalences among AI/ANs compared to NHWs. Exclusion of Hispanic ethnicity from the AI/AN category had little impact on birth defects prevalences in AI/ANs. NHWs serve as a viable comparison group for analysis. Birth defects among AI/ANs require additional scrutiny to identify modifiable risk and protective factors.

KEYWORDS

Alaska Natives, American Indians, birth defects surveillance, congenital abnormalities, population health

1 | INTRODUCTION

Published literature contains limited information pertaining to major birth defects in the American Indian/Alaska Native (AI/AN) population. However, a number of studies have reported a high prevalence of orofacial clefts (Aggarwal, Warmerdam, Wyatt, Ahmad, & Shaw, 2015; Croen, Shaw, Wasserman, & Tolarová, 1998; Jaffe, 1969; Jaffe & De Blanc, 1970; Lowry & Renwick, 1969; Lowry, Thunem, & Silver, 1986; Niswander & Adams, 1967; Niswander, Barrow, & Bingle, 1975; Tretsven, 1963), abdominal wall defects (Mohamed & Aly, 2012), and anotia/microtia (Aase & Tegtmeier, 1977; Aggarwal et al., 2015; Jaffe, 1969; Jaffe & De Blanc, 1970; Luquetti, Leoncini, & Mastroiacovo, 2011)

in the AI/AN population. While a recent study from the National Birth Defects Prevention Network (NBDPN) identified several birth defects with significantly higher prevalence among non-Hispanic AI/ANs compared to non-Hispanic whites (NHWs) (Canfield et al., 2014), the study classified AI/ANs and other racial/ethnic groups as non-Hispanic, to distinguish from Hispanics of any race. This categorization is based on the Office of Management and Budget (OMB) classification of race and ethnicity (OMB, 1997). However, several federal documents [*Race and Ethnic Standards for Federal Statistics and Administrative Reporting* (OMB, 1997), U.S. Census Bureau documents (USC Bureau, 2012), and National Health Statistics reports (Barnes, Adams, & Powell-Griner, 2010)] define AI/AN as "a person with origins in any of the original peoples of North and South America (including Central America) and who maintains tribal affiliation or community attachment."

The birth defects studies conducted to date have typically followed the OMB convention, evaluating AI/ANs who reported no other race and who were of non-Hispanic ethnicity; those AI/ANs who report Hispanic ethnicity are included in the Hispanic category (OMB, 1997; Barnes et al., 2010; Canfield et al., 2014; Croen et al., 1998; Luquetti et al., 2011; Mai et al., 2014; Mohamed & Aly, 2012; Parker et al., 2010). However, these criteria effectively encompass only about half of the U.S. AI/AN population. According to the 2010 U.S. Census, 44% of the AI/AN population also report one or more other races and almost a quarter (23.4%) of the AI/AN population also reports Hispanic ethnicity. To account for this heterogeneity, U.S. Census reports currently categorize AI/AN into three overlapping categories: (1) American Indian/Alaska Native alone; (2) American Indian/Alaska Native in combination with any other race; and (3) American Indian/Alaska Native alone or in combination with one or more races (Barnes et al., 2010; USC Bureau, 2011a; USC Bureau, 2012). Additionally, the 2010 U.S. Census reports that the majority of the AI/AN population resides in 10 states: California, Oklahoma, Arizona, Texas, New York, New Mexico, Washington, North Carolina, Florida, and Michigan (USC Bureau, 2012). Six of these states were included in the pooled NBDPN dataset analyzed by Canfield et al. (2014): Arizona, Texas, New York, North Carolina, Florida, and Michigan.

This study examined selected birth defects found in the recently published NBDPN study (Canfield et al., 2014) to have higher prevalence within the non-Hispanic AI/AN population. We also examined cleft palate alone, which although not statistically different from NHWs in the NBDPN study, comprised an important component of orofacial clefts as a whole, and was not clearly differentiated from other orofacial clefts in other studies (Aggarwal et al., 2015; Croen et al., 1998; Jaffe, 1969; Jaffe & De Blanc, 1970; Lowry et al., 1986; Lowry & Renwick, 1969; Niswander & Adams, 1967; Niswander et al., 1975; Tretsven, 1963). Additionally, we explored different methods for tabulating AI/ANs by factoring in Hispanic ethnicity, and we compared the prevalence of birth defects among AI/ANs to the prevalence among both NHWs and Hispanics. Finally, we adjusted for additional covariates that included maternal risk factors such as diabetes and smoking.

2 | METHODS

2.1 | Data source

The NBDPN is a collaboration of state birth defects surveillance programs across the United States (www.nbdpn.org). This study was a subanalysis of a previously published NBDPN study using pooled data from 12 population-based birth defects surveillance programs that supplied anonymized individual-level data for both birth defect cases and selected demographics data from each state (Canfield et al., 2014). Selected sociodemographic and other variables for the birth defects cases were obtained from their linked birth or fetal death vital records to supplement birth defect registry data (i.e., gestational age at delivery, maternal smoking, timing of prenatal care, maternal diabetes, and maternal education). Participating surveillance programs utilize either active or passive case-finding methodology for abstracting birth defects case data. Programs could report up to 24 birth defects diagnoses for each case. Active case-finding programs included Arizona, Georgia (Metropolitan Atlanta), Massachusetts, North Carolina, and Texas, whereas passive case-finding programs included Colorado, Florida, Illinois, Michigan, Nebraska, New Jersey, and New York State (excluding New York City). Michigan did not contribute data for gastroschisis, and the following five states were unable to exclude possible/probable diagnoses: Colorado, Florida, Illinois, Michigan, and New York. Programs provided live-born cases and cases among other pregnancy outcomes, where available. The NBDPN data collection has been previously reported (NBDPN, 2012; Parker et al., 2010). Texas served as the deferring Institutional Review Board (IRB) with the Centers for Disease Control and Prevention (CDC) serving as the data repository.

2.2 | Study population

Cases were infants and fetuses delivered during 1999–2007 with any of the seven types of birth defects that were found in the previously published NBDPN study to have a statistically significant elevation in prevalence among non-Hispanic AI/ANs compared to NHWs (Canfield et al., 2014). These birth defects included encephalocele, anotia/microtia, cleft lip with or without (+/−) cleft palate, upper limb reduction defects, lower limb reduction defects, gastroschisis, and trisomy 18. Additionally, all cases with cleft

palate alone were included to examine whether this defect was elevated among AI/ANs, as previously reported in other studies. An individual case with more than one of the specified birth defects was counted in each relevant category. Variables were limited to those available from the prior NBDPN study (Canfield et al., 2014).

2.3 | AI/AN race and Hispanic ethnicity categorization

We explored the effect of different methods of categorizing AI/ANs. We started by identifying all cases indicating maternal AI/AN race, and then created two AI/AN categories to align with the U.S. Census: (1) Any AI/AN, regardless of Hispanic ethnicity, and (2) non-Hispanic AI/AN. The two comparison referent groups were NHWs and non-AI/AN Hispanics.

2.4 | Analyses

Birth defects prevalence was calculated as the count of cases per 10,000 live births; 95% confidence intervals (95% CI) were determined using Poisson regression in SAS 9.4 (SAS Institute, Cary, NC). We calculated crude and adjusted prevalence ratios for each categorization of AI/AN (non-Hispanic AI/AN, any AI/AN) and for each of the birth defect categories. Crude and adjusted prevalence ratios were generated separately using the two referent groups. Variables for adjustment were selected a priori based on their association with birth defects in previous studies and availability of data in this study. Variables included maternal age (<20, 20–34, and 35+ years), education (less than high school, high school, and greater than high school), any indication of gestational or prepregnancy diabetes, smoking during the pregnancy, type of birth defect surveillance program (active versus passive case finding), and year of delivery. We excluded variables with 10% or more missing values from the multivariable analysis (i.e., timing of prenatal care and gestational age at delivery). We conducted forward stepwise selection modeling of variables to obtain the multivariable model. Variables with 10% or greater change in any stratum-specific adjusted prevalence ratio were retained in the final model. The final adjusted model contained maternal age, education, any indication of diabetes, smoking, and type of case-finding surveillance program. We examined the AI/AN case data for any co-occurring chromosomal anomalies. We also examined the potential impact of Arizona data in the pooled adjusted analysis because the state program contributed more than 50% of the AI/AN data.

3 | RESULTS

The study included a total of 456 infants who were affected by a birth defect out of 104,338 live AI/AN births. The percentage of AI/AN mothers who also reported Hispanic ethnicity was 11.7% (12,251), lower than what is suggested in the census data (USC Bureau, 2011a). Descriptive statistics for infants and fetuses with any of the eight birth defects studied in this analysis are shown in Table 1. Southwestern states with their relatively large Hispanic populations are heavily represented: about two-thirds of the AI/AN mothers in this study resided in Arizona, Colorado, and Texas. Arizona alone contributed more than 50% of the AI/AN data.

Among the cases of birth defects, NHW mothers were more likely to have reported smoking (16%), compared to either category of AI/ANs (10%), while non-AI/AN Hispanics (3%) were the least likely to smoke (Table 1). They were also more likely to be older and have attained postsecondary education (53%). Non-AI/AN Hispanic mothers of birth defects cases had the lowest level of educational attainment, with 48% receiving less than a high-school education. Both non-Hispanic AI/ANs (30%) and any AI/ANs (31%) were less likely to have less than a high-school education. Also among birth defects cases, the percentage of mothers with diabetes was higher for both categories of AI/ANs (8%) compared to NHWs (4%) and non-AI/AN Hispanics (5%). The pattern of elevated diabetes in AI/AN was noted among live births in the population.

Table 2 depicts the prevalence, crude prevalence ratios, and adjusted multivariable results for the birth defects under investigation for non-Hispanic AI/ANs and any AI/ANs regardless of Hispanic ethnicity, compared to NHW mothers. In the earlier Canfield et al. (2014) analysis, which controlled for only maternal age and US state, non-Hispanic AI/AN had a 50% or greater increased prevalence for all of these birth defects except cleft palate alone when compared to NHWs. For oral clefts, we confirmed that the prevalence for cleft lip +/− cleft palate is significantly higher, but not for cleft palate alone. After adjustment for maternal age, education, any indication of diabetes, smoking, and type of surveillance program, the adjusted prevalence ratios for non-Hispanic AI/ANs compared to NHWs were statistically significant only for cleft lip +/− cleft palate [adjusted prevalence ratio (aPR) = 1.69 (95% CI 1.41–2.01)] and anotia/microtia [aPR = 2.72 (95% CI 1.55–4.45)]. A third condition, trisomy 18, had a 52% higher prevalence, which was not significant after adjustment [aPR = 1.52 (95% CI 0.97–2.27)]. Similar findings were seen for any AI/AN regardless of Hispanic ethnicity. Inclusion of AI/AN mothers who were also of Hispanic ethnicity resulted in negligible differences in results. When the models excluded Arizona data, cleft lip +/− cleft palate remained significant [aPR = 1.49 (95% CI 1.12–1.93)], but anotia/microtia lost statistical significance (NH AI/AN: aPR = 1.41, 95% CI 0.31–3.90; Any AI/AN: aPR = 1.76, 95% CI 0.53–4.20).

The majority of AI/AN cases for the birth defects examined did not have a co-occurring chromosomal condition. Nine infants and fetuses with cleft lip +/− cleft palate (4%)

TABLE 1 Study descriptive statistics for infants and fetuses with birth defects, 12 U.S. Birth Defects Surveillance Programs, 1999–2007

	Non-Hispanic American Indian/Alaska Native		Any American Indian/ Alaska Native, regardless of Hispanic ethnicity		Non-Hispanic White		Hispanic, Not American Indian/Alaska Native	
	Cases (%)	Denominator (%)	Cases (%)	Denominator (%)	Cases (%)	Denominator (%)	Cases (%)	Denominator (%)
Pregnancy outcome[a]								
Live birth	342 (82.4%)	92,087 (100%)	379 (83.1%)	104,338 (100%)	14,134 (77.4%)	7,195,012 (100%)	9,564 (89.8%)	3,756,929 (100%)
Nonlive birth	15 (3.6%)		17 (3.7%)		620 (3.4%)		581 (5.5%)	
Unknown/not reported	58 (14.0%)		60 (13.2%)		3,501 (19.2%)		509 (4.8%)	
Gestational age (GA)[b]								
GA < 24 weeks	7 (1.7%)	200 (0.2%)	8 (1.8%)	226 (0.2%)	323 (1.8%)	9,891 (0.1%)	284 (2.7%)	7,518 (0.2%)
GA 24–36 weeks (PTB)	122 (29.4%)	8,165 (8.9%)	132 (28.9%)	9,317 (8.9%)	3,490 (19.1%)	531,682 (7.4%)	2,523 (23.7%)	316,265 (8.4%)
GA 37–44 weeks (term)	244 (58.8%)	71,888 (78.1%)	265 (58.1%)	81,159 (77.8%)	10,006 (54.8%)	4,951,479 (68.8%)	6,703 (62.9%)	3,093,181 (82.3%)
Unknown/not reported	42 (10.1%)	11,834 (12.9%)	51 (11.2%)	13,636 (13.1%)	4,436 (24.3%)	1,701,960 (23.7%)	1,144 (10.7%)	339,965 (9.0%)
Maternal education								
<High school	125 (30.1%)	27,838 (30.2%)	141 (30.9%)	32,624 (31.3%)	2,585 (14.2%)	735,524 (10.2%)	5,156 (48.4%)	1,733,885 (46.2%)
High school	171 (41.2%)	32,915 (35.7%)	185 (40.6%)	36,857 (35.3%)	5,613 (30.7%)	1,915,413 (26.6%)	2,993 (28.1%)	1,094,982 (29.1%)
>High school	112 (27.0%)	29,948 (32.5%)	121 (26.5%)	33,183 (31.8%)	9,646 (52.8%)	4,455,419 (61.9%)	2069 (19.4%)	868,356 (23.1%)
Unknown	7 (1.6%)	1,386 (1.5%)	9 (1.9%)	1,674 (1.6%)	411(2.3%)	88,656 (1.2%)	436 (4.1%)	59,706 (1.6%)
Maternal age group								
<20 years	80 (19.3%)	16,191 (17.6%)	88 (19.3%)	18,603 (17.8%)	1989 (10.9%)	504,088 (7.0%)	2093 (19.7%)	586,343 (15.6%)
20–34 years	293 (70.6%)	67,129 (72.9%)	323 (70.8%)	75,802 (72.7%)	13,231 (72.5%)	5,402,330 (75.1%)	7,307 (68.6%)	2,803,683 (74.6%)
35+ years	42 (10.1%)	8,756 (9.5%)	45 (9.9%)	9,922 (9.5%)	3,026 (16.6%)	1,287,775 (17.9%)	1,251 (11.7%)	366,539 (9.8%)
Unknown	0 (0.0%)	11 (0.0%)	0 (0.0%)	11 (0.0%)	9 (0.0%)	819 (0.0%)	3 (<.1%)	364 (0.0%)
Maternal diabetes								
Diabetes, any	34 (8.2%)	5,539 (6.0%)	36 (7.9%)	6,109 (5.9%)	670 (3.7%)	213,131 (3.0%)	537 (5.0%)	133,327 (3.5%)
Not diabetic	354 (85.3%)	81,390 (88.4%)	387 (84.9%)	91,002 (87.2%)	15,863 (86.9%)	5,916,883 (82.2%)	9,318 (87.5%)	3,300,764 (87.9%)
Unknown	27 (6.5%)	5,158 (5.6%)	33 (7.2%)	7,227 (6.9%)	1,722 (9.4%)	1,064,998 (14.8%)	799 (7.5%)	322,838 (8.6%)
Prenatal care (PNC)[b]								
No PNC	9 (2.2%)	1,798 (2.0%)	9 (2.0%)	2059 (2.0%)	166 (0.9%)	39,060 (0.5%)	314 (2.9%)	86,140 (2.3%)
PNC first trimester	262 (63.1%)	54,048 (58.7%)	284 (62.3%)	60,858 (58.3%)	10,763 (59.0%)	4,485,395 (62.3%)	6,072 (57.0%)	2,279,165 (60.7%)
PNC second trimester	83 (20%)	17,413 (18.9%)	88 (19.3%)	19,816 (19.0%)	1,671 (9.2%)	562,141 (7.8%)	2025 (19.0%)	709,853 (18.9%)
PNC third trimester	16 (3.9%)	4,755 (5.2%)	19 (4.2%)	5,537 (5.3%)	302 (1.7%)	100,979 (1.4%)	434 (4.1%)	164,719 (4.4%)
Unknown/not reported	45 (10.8%)	14,073 (15.3%)	56 (12.3%)	16,068 (15.4%)	5,353 (29.3%)	2,007,437 (27.9%)	1809 (17.0%)	517,052 (13.8%)
Maternal smoking during the pregnancy								
Smoked	43 (10.4%)	10,564 (11.5%)	47 (10.3%)	11,446 (11.0%)	2,993 (16.4%)	845,038 (11.7%)	305 (2.9%)	82,220 (2.2%)
Did not smoke	357 (86.0%)	78,184 (84.9%)	394 (86.4%)	88,997 (85.3%)	14,605 (80.0%)	5,710,883 (79.4%)	9,959 (93.5%)	3,557,631 (94.7%)
Unknown	15 (3.6%)	3,339 (3.6%)	15 (3.3%)	3,895 (3.7%)	657 (3.6%)	639,091 (8.9%)	390 (3.7%)	117,078 (3.1%)
State of residence[c]								
Arizona	242 (58.3%)	47,894 (52.0%)	259 (56.8%)	53,880 (51.6%)	905 (5.0%)	351,577 (4.9%)	1,053 (9.9%)	351,026 (9.3%)
Georgia (Metro Atlanta)	3 (0.7%)	794 (0.9%)	4 (0.9%)	1,026 (1.0%)	401 (2.2%)	187,244 (2.6%)	199 (1.9%)	70,272 (1.9%)
Colorado	14 (3.4%)	4,268 (4.6%)	21 (4.6%)	5,561 (5.3%)	1,074 (5.9%)	374,236 (5.2%)	607 (5.7%)	183,905 (4.9%)
Florida	12 (2.9%)	5,466 (5.9%)	18 (3.9%)	7,559 (7.2%)	2,400 (13.1%)	938,107 (13.0%)	997 (9.4%)	503,707 (13.4%)
Illinois	6 (1.4%)	2,144 (2.3%)	8 (1.8%)	2,452 (2.4%)	1941 (10.6%)	899,802 (12.5%)	754 (7.1%)	375,856 (10.0%)
Massachusetts	3 (0.7%)	1,316 (1.4%)	3 (0.7%)	1,381 (1.3%)	941 (5.2%)	440,277 (6.1%)	187 (1.8%)	64,940 (1.7%)
Michigan	17 (4.1%)	5,975 (6.5%)	19 (4.2%)	6,236 (6.0%)	2,241 (12.3%)	853,288 (11.9%)	172 (1.6%)	68,725 (1.8%)
North Carolina	38 (9.2%)	8,278 (9.0%)	38 (8.3%)	8,393 (8.0%)	1,015 (5.6%)	354,042 (4.9%)	273 (2.6%)	96,074 (2.6%)
Nebraska	19 (4.6%)	3,693 (4.0%)	19 (4.2%)	3,939 (3.8%)	529 (2.9%)	171,235 (2.4%)	93 (0.9%)	29,766 (0.8%)
New Jersey	2 (0.5%)	1,175 (1.3%)	2 (0.4%)	1,563 (1.5%)	994 (5.4%)	525,139 (7.3%)	596 (5.6%)	228,850 (6.1%)
New York[d]	19 (4.6%)	4,443 (4.8%)	21 (4.6%)	4,798 (4.6%)	1967 (10.8%)	858,520 (11.9%)	317 (3.0%)	143,387 (3.8%)
Texas	40 (9.6%)	6,641 (7.2%)	44 (9.6%)	7,550 (7.2%)	3,847 (21.1%)	1,241,545 (17.3%)	5,406 (50.8%)	1,640,421 (43.7%)
Surveillance method[e]								
Active case-finding	326 (78.6%)	64,923 (70.5%)	348 (76.3%)	72,230 (69.2%)	7,109 (38.9%)	2,574,685 (35.8%)	7,118 (66.8%)	2,222,733 (59.2%)
Passive case-finding	89 (21.4%)	27,164 (29.5%)	108 (23.7%)	32,108 (30.8%)	11,146 (61.1%)	4,620,327 (64.2%)	3,536 (33.2%)	1,534,196 (40.8%)

(*Continues*)

TABLE 1 (Continued)

	Non-Hispanic American Indian/Alaska Native		Any American Indian/Alaska Native, regardless of Hispanic ethnicity		Non-Hispanic White		Hispanic, Not American Indian/Alaska Native	
	Cases (%)	Denominator (%)	Cases (%)	Denominator (%)	Cases (%)	Denominator (%)	Cases (%)	Denominator (%)
Delivery years								
1999–2001	111 (26.7%)	26,399 (28.7%)	124 (27.2%)	31,449 (30.1%)	5,643 (30.9%)	2,302,568 (32.0%)	2,938 (27.6%)	1,077,704 (28.7%)
2002–2004	150 (36.1%)	31,207 (33.9%)	168 (36.8%)	35,302 (33.8%)	6,092 (33.4%)	2,423,377 (33.7%)	3,561 (33.4%)	1,266,111 (33.7%)
2005–2007	154 (37.1%)	34,479 (37.4%)	164 (36.0%)	37,585 (36.0%)	6,520 (35.7%)	2,468,787(34.3%)	4,155 (39.0%)	1,413,078 (37.6%)
Total	415 (100%)	92,087 (100%)	456 (100%)	104,338 (100%)	18,255 (100%)	7,195,012 (100%)	10,654 (100%)	3,756,929 (100%)

Note. Abbreviations: GA = clinical estimation of gestational weeks; PNC = start of prenatal care by trimester; PTB = preterm birth.
[a] Programs that did not report any pregnancy outcome: Michigan and North Carolina.
[b] Programs that did not report any gestational ages nor prenatal care timing: Colorado, Michigan, and Massachusetts.
[c] Passive case-finding surveillance programs: Colorado, Florida, Illinois, Michigan, Nebraska, New Jersey, and New York (excludes New York city); active case-finding surveillance programs: Arizona, Georgia (Metro Atlanta), Massachusetts, North Carolina, and Texas.
[d] New York state, excludes New York City.

had co-occurring chromosomal anomalies, three of which were trisomy 18, five were trisomy 13, and one was 22q11 deletion. Three infants and fetuses with cleft palate alone (5%) had various chromosomal anomalies (none of which were trisomy 18 or trisomy 13). Three infants and fetuses with anotia/microtia (6%) had co-occurring chromosomal diagnoses (all were trisomy 18). One child with gastroschisis had co-occurring trisomy 18, and one child who had both upper and lower limb reduction defects had trisomy 13. Only cases with encephalocele had no co-occurring chromosomal anomalies reported.

4 | DISCUSSION

Adjusted prevalences for anotia/microtia and cleft lip +/− cleft palate among AI/ANs remained significantly elevated compared to NHWs after adjustment for maternal age, education, any indication of diabetes, smoking, and type of case-finding surveillance program. This remained unchanged when the AI/AN group was examined regardless of Hispanic ethnicity. Trisomy 18 results did not reach significance. Furthermore, removal of the Arizona data showed that elevated anotia/microtia prevalences were driven by the Arizona population

TABLE 2 Prevalence, crude, and adjusted prevalence ratios for selected birth defects among American Indian/Alaska Native by Hispanic ethnicity, 12 U.S. Birth Defects Surveillance Programs, 1999–2007

Defect	Non-Hispanic White[a] (referent)		Non-Hispanic American Indian/Alaska Native[a]				Any American Indian/Alaska Native, regardless of Hispanic ethnicity[a]			
	Cases	Prevalence[b] (95% CI)	Cases	Prevalence[b] (95% CI)	cPR (95% CI)	aPR[c] (95% CI)	Cases	Prevalence[b] (95% CI)	cPR (95% CI)	aPR[c] (95% CI)
Encephalocele	444	0.62 (0.56–0.67)	13	1.41 (0.75–2.41)	2.29 (1.25–3.80)	1.78 (0.36–5.30)	14	1.34 (0.73–2.25)	2.17 (1.22–3.55)	1.74 (0.40–4.89)
Anotia/microtia	843	1.17 (1.09–1.25)	43	4.67 (3.38–6.29)	3.99 (2.89–5.34)	2.72 (1.55–4.45)	49	4.7 (3.47–6.21)	4.01 (2.97–5.28)	2.75 (1.62–4.36)
Cleft lip +/− cleft palate	6,955	9.67 (9.44–9.89)	185	20.09 (17.19–22.98)	2.08 (1.79–2.40)	1.69 (1.41–2.01)	203	19.46 (16.78–22.13)	2.01 (1.75–2.31)	1.65 (1.39–1.95)
Cleft palate alone[d]	4,573	6.36 (6.17–6.54)	60	6.52 (4.97–8.39)	1.03 (0.79–1.31)	N/A	65	6.23 (4.81–7.94)	0.98 (0.76–1.24)	N/A
Gastroschisis[e]	1967	3.1 (2.96–3.24)	59	6.85 (5.22–8.84)	2.21 (1.69–2.83)	1.12 (0.76–1.57)	64	6.52 (5.02–8.33)	2.10 (1.62–2.67)	1.07 (0.74–1.49)
Upper limb reductions	1985	2.76 (2.64–2.88)	40	4.34 (3.10–5.91)	1.57 (1.13–2.12)	1.15 (0.75–1.67)	43	4.12 (2.98–5.55)	1.49 (1.09–1.99)	1.06 (0.70–1.53)
Lower limb reductions	1,079	1.5 (1.41–1.59)	24	2.61 (1.67–3.88)	1.74 (1.13–2.54)	1.37 (0.81–2.18)	26	2.49 (1.63–3.65)	1.66 (1.10–2.40)	1.36 (0.82–2.11)
Trisomy 18	1,168	1.62 (1.53–1.72)	26	2.82 (1.84–4.14)	1.74 (1.15–2.51)	1.52 (0.97–2.27)	28	2.68 (1.78–3.88)	1.65 (1.11–2.35)	1.52 (0.99–2.23)

Note. Abbreviations: aPR = adjusted Prevalence Ratio; CI = Confidence Interval; cPR = crude Prevalence Ratio; +/− = with or without.
[a] Denominators (number of total live births): all birth defects except gastroschisis (non-Hispanic white = 7,195,012; non-Hispanic AI/AN = 92,087; any AI/AN = 104,338); Gastroschisis[e] denominators (non-Hispanic white = 6,341,724; non-Hispanic AI/AN = 86,112; any AI/AN = 98,102).
[b] Prevalence = number of cases/number of total live births × 10,000.
[c] Adjusted for maternal age, education, any indication of diabetes, smoking, and type of case-finding surveillance program.
[d] Cleft palate was not adjusted as the crude prevalence was not statistically significant. Cleft palate was included to show which oral cleft was elevated among American Indian/Alaska Native.
[e] Excludes Michigan data.

and did not remain statistically significant, although this was based on small numbers of cases. A recent paper on birth defect prevalence variability found that anotia/microtia, especially among Hispanics, had wide variability with active surveillance systems reporting around a 50% higher prevalence for anotia/ microtia, compared with passive surveillance systems (Mai et al., 2015). This elevated prevalence of anotia/ microtia for Arizona merits further consideration.

Although it is possible to report multiple races with the U.S. 2003 Standard Certificate of Live Birth, very few of the participating states had adopted the new vital record format permitting multiple race reporting during our study time period. As a result, we were unable to evaluate two of the three U.S. Census categorizations. We categorized AI/ANs as non-Hispanic AI/ANs, comparable to the U.S. Census category of AI/ANs alone, and as any AI/AN regardless of Hispanic ethnicity, to address concerns over the standard practice of including as Hispanic those individuals who report AI/AN race in addition to report Hispanic ethnicity. We found 11.7% of all AI/AN mothers in our study also reported Hispanic ethnicity. This was half of the 23.4% of the AI/AN population who were also Hispanic as reported in the 2010 U.S. Census (USC Bureau, 2011a). Our study included 6 of the 10 states, where the majority of the U.S. AI/AN population resided in 2010, California and Oklahoma, the two states with the greatest numbers of AI/AN residents did not participate (USC Bureau, 2011b).

This study had several limitations. First, even with pooled data from 12 states over 9 years, some of the birth defect case counts were relatively small. Five states were unable to separate possible diagnoses from definite which may have inflated some of the case counts from their states. We grouped the states into active versus passive surveillance system to address some of the small number issues and to control for the different surveillance systems. In the forward selection process, a number of prevalence and prevalence ratio calculations were based on cell sizes of fewer than five cases, leading to wide confidence intervals due to imprecise estimates. However, several comparisons were statistically different from the NHW reference group even with wide confidence intervals. Our study was also heavily weighted by southwestern states for the AI/AN population. For example, we found that the Arizona data drove the elevated anotia/microtia prevalence. Additionally, not all states include all pregnancy outcomes, that is, terminations. If pregnancy termination is utilized unequally across states or race and ethnic groups, there might be differential under-ascertainment for some of these birth defects (Cragan & Gilboa, 2009). For covariate data derived from linked vital records, while we would not expect differential under-ascertainment, there could be an under-ascertainment of the true prevalence of the risk factors (Lydon-Rochelle et al., 2005). For example, diabetes was more prevalent among AI/ANs even with the known under-ascertainment in the vital records, which may only capture 52% of the true diabetes cases (Lydon-Rochelle et al., 2005). Finally, as most states had not adopted the new vital record format, we were unable to evaluate maternal obesity or to examine smoking and diabetes in more detail.

Our study results are also limited in the level of detail concerning the AI/AN births included in the analysis. The AI/AN population in the United States is diverse culturally, genetically, and socioeconomically, with non-Indian race intermarriages and varying utilization of medical care delivery systems. There are currently 573 federally recognized tribes with many other tribes seeking Federal recognition (USDI, 2018). Because of this heterogeneity of the AI/AN population, these findings may not apply to all tribes.

Strengths of this study lie in the inclusion of population-based birth defects data using multiple data source methodologies from 12 U.S. states with ~11 million live births that span over a time period of almost a decade. This is one of the largest population-based studies of birth defects among AI/ANs in the country, which permitted multivariable analysis for these birth defects. Additionally, the birth defects examined are generally considered to be consistently diagnosed across all participating states (Canfield et al., 2006).

The adjustments for maternal age, education, diabetes status, smoking, and type of case-finding surveillance program performed in this study affected the previously reported higher prevalences for selected birth defects among the AI/AN population (Canfield et al., 2014). We ascertained that the majority of the cases among AI/AN infants for the birth defects examined did not have co-occurring chromosomal conditions. The increased prevalence of cleft lip +/− cleft palate and anotia/microtia show an increased need for rehabilitation services including hearing and speech services for these individuals. The statistically elevated prevalence of anotia/microtia observed in the Arizona AI/AN population merits further evaluation.

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CONFLICT OF INTEREST

The authors declared that they have no conflicts of interest to report.

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