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Is the Prevalence of Specific Types of Congenital Heart Defects Different for Non-Hispanic White, Non-Hispanic Black and Hispanic Infants?

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Abstract *Background* Our purpose was to determine the prevalence of specific types of CHD among non-Hispanic (NH)-Black, NH-White, and Hispanic infants. *Methods* We conducted a retrospective cohort study with 9,352 singleton infants diagnosed with conotruncal, right or left obstructive or septal CHDs from the Florida Birth Defects Registry, born 1998–2003 to resident NH-White, NH-Black, and Hispanic women aged 15–49. Defect-specific prevalence rates, prevalence ratios and *P*-values were calculated for each type of CHD and by number of defects for each racial/ethnic group. *Results* Compared to NH-Whites, NH-Blacks had higher rates of pulmonary valve atresia/stenosis but lower frequency of aortic valve atresia/stenosis and ventricular septal defect. Hispanics had lower rates of aortic valve atresia/stenosis and atrioventricular septal defects than NH-Whites. *Conclusions* Although few racial/ethnic differences in prevalence are present among infants with major CHD, observed differences are clinically meaningful. However, the underlying etiologies for the observed differences remain unknown.

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Introduction

Birth defects are the leading cause of infant morbidity and mortality in the United States and congenital heart defects (CHD) are the most common of all birth defects with an annual prevalence ranging from six to twelve affected infants per 1,000 live births [1–4]. Only 5–10% of CHDs are attributed to chromosomal abnormalities and single gene defects. While the exact etiology of most cases of CHDs remains unknown, several well-established modifiable factors are associated with increased risk of congenital heart defects. Some maternal illnesses such as phenylketonuria (PKU), diabetes, rubella, maternal febrile illnesses, and influenza increase the risk of a CHD-affected pregnancy. Reported increased risks range from an odds ratio of 1.6 (febrile illness and conotruncal defects) to an odds ratio of 27.2 (maternal diabetes and d-transposition of the great arteries (d-TGA)) [5]. High vitamin A intake and use of certain therapeutic drugs during pregnancy, specifically, anticonvulsants, thalidomide, sulfasalazine, and vitamin A congeners/retinoids, also increases risk of CHD. While the results of studies investigating the effect of environmental exposures on CHD risk are inconclusive, organic solvents are associated with increased risk of CHD [5]. In contrast, the association between sociodemographic factors, such as maternal and paternal age, socioeconomic status, and prenatal maternal stress is inconsistent [5].

The role of another important sociodemographic factor, maternal race/ethnicity, is also unclear [5]. Few studies provide race-specific prevalence estimates for types of CHD and results are inconclusive [3, 6–11]. Some studies

report excess risk of specific types of CHDs for Whites compared to Blacks and very few studies have reported risk of specific types of CHD for Hispanics. Moreover, few studies provide information on the prevalence of isolated, multiple heart and CHD with non-cardiac defects by maternal race/ethnicity. Hence, the intent of this investigation was to (1) determine the prevalence of CHD at live birth and (2) determine the prevalence of isolated CHD, multiple heart and CHD plus non-cardiac defects for non-Hispanic (NH)-White, NH-Black and Hispanic infants.

Materials and Methods

Case Ascertainment

We conducted a retrospective cohort study using data from the Florida Birth Defects Registry (FBDR), a passive population-based surveillance system. Since 1998 the FBDR has monitored birth defects in Florida by merging data from (1) Florida Vital Statistics Birth data; (2) Agency for Health Care Administration (AHCA) hospital discharge data; (3) Children's Medical Services (CMS) Regional Perinatal Intensive Care Center (RPICC) data; (4) CMS Early Steps data; and (5) the CMS Minimum data set. The FBDR employs a deterministic merging strategy to link source data sets to birth vital records, using variables such as mother and child's names, social security numbers, dates of birth, and infant sex. All questionable links are manually reviewed. The success rate for the linkage process ranges from approximately 85% in the AHCA inpatient data set, to over 95% in the RPICC data set. Infants are included in the FBDR if they are live-born to a Florida resident and have an included birth defect as coded by the International Classification of Diseases, Ninth edition, Clinical Modification (ICD-9-CM) diagnosis coding system.

Classification of Congenital Heart Defects

We selected all live-born, singleton infants diagnosed with a CHD in the first year of life, born between 1 January 1998 and 31 December 2003 to Florida resident women, 15–49 years of age. CHDs were classified using select ICD-9-CM diagnosis codes in the 745.00–747.99 range and were placed into four categories: (1) conotruncal, (2) right obstructive, (3) left obstructive and (4) septal CHD. The conotruncal CHD category included common truncus arteriosus (745.0), transposition of the great arteries (745.10–745.12 or 745.19), and tetralogy of Fallot (745.2). Right obstructive CHDs included tricuspid valve atresia and stenosis (746.1), pulmonary valve atresia and stenosis (746.01 or 746.02) and Ebstein's anomaly (746.2). Left obstructive CHDs included hypoplastic left heart syndrome (746.7), aortic valve stenosis (746.3), and coarctation of the aorta (747.10). Septal CHDs included ventricular septal defect (745.4), and atrioventricular septal defect (745.60, 745.61, or 745.69).

We then sub-classified cases into three categories based on the number and type of birth defects: (1) isolated CHD, (2) multiple heart defects and (3) non-cardiac defects. If an infant had one of the selected CHDs and no non-cardiac defects diagnosed within the first year of life, he/she had an 'isolated heart defect'. If an infant had more than one of the selected CHD types diagnosed within the first year of life but no non-cardiac defects, he/she was classified as having 'multiple heart defects'. Infants with known chromosomal abnormalities and/or syndromes were excluded from the 'isolated' and 'multiple' heart defect categories. Infants were placed in the 'non-cardiac defect' group if they had at least one of the 12 CHDs and one or more non-cardiac defects (identified using select ICD-9-CM codes in the 740.00–754.99 range).

Study Variables

Data on maternal race/ethnicity were taken from the Florida Office of Vital Statistics live birth certificate. Maternal race/ethnicity was determined based on maternal self-report and was first grouped by ethnicity (Hispanic or non-Hispanic) and the non-Hispanic group was sub-divided into White, Black, and other. We use the term *Hispanic* to refer to people of Spanish, Hispanic or Latino origin. We realize that the term *Hispanic* is a non-specific term that includes diverse groups (e.g., immigrants from Puerto Rico, Cuba, Mexico, and South America) and prevalence estimates may differ among these groups. However, due to our sample size and limited information on country of origin, we have included all Hispanic/Spanish/Latin ethnicities in the category *Hispanic* which is consistent with the practice of the U.S. Census Bureau and Florida Department of Health.

Data Analysis

We calculated race/ethnic-specific prevalence estimates for each type of CHD by dividing the number of cases of CHD by the number of live births during the study period for each racial/ethnic group (per 10,000 live births). The exact 95% confidence interval (CI) for each prevalence rate was obtained by the Clopper-Pearson method [12]. Prevalence rate ratios (PR) were calculated by dividing the prevalence rate for NH-Blacks and Hispanics by the prevalence rate for NH-Whites (referent group). For each table, the Bonferroni simultaneous CIs for 26 prevalence ratios were obtained based on normal approximation on the log-scale [13, 14]. Specifically, each CI is constructed with

confidence coefficient (1 – 0.05/26 = 99.81%) and the Bonferroni inequality ensures the overall confidence coefficient is at least 95%. Based on the relationship between CI and hypothesis testing, a prevalence ratio is considered to be significantly different from one if its CI does not contain one. By using simultaneous CIs with an overall confidence coefficient at least 95% for multiple testing, the family wise error rate [15] is controlled to be no greater than 5%. We also report the corresponding Bonferroni corrected *P*-value (statistical significance is $P < .002$). The statistical software, R 2.4.1 [16] was used for all analyses.

Institutional Review Board

The Office of Research Integrity and Compliance, Institutional Review Board at the University of South Florida approved the study. The FDOH Institutional Review Board approved the study and the use of data from Florida birth records and FBDR data.

Results

During the study period, 1,216,142 infants were live births to Florida residents. Of these live births, 10,027 had at least one of the selected CHD. We excluded 675 (6.7%) infants from our study population because they were not a singleton birth ($n = 424$), had a maternal race/ethnicity designated as "Other" ($n = 223$), or had a maternal age <15 or >49 years ($n = 28$) (some infants had more than one exclusion). Our final study population included 9,352 infants with CHD, of which 4,982 (53.3%) were born to NH-White, 2,104 (22.5%) were born to NH-Black, and 2,266 (24.2%) were born to Hispanic women.

Prevalence of Congenital Heart Defects

As shown in Table 1, Hispanic infants had the highest overall CHD prevalence (80.09 per 10,000 live births) followed by NH-White (79.11 per 10,000 live births) and NH-Black infants (77.67 per 10,000 live births). There were few statistically significant racial/ethnic differences in rates of conotruncal, right obstructive, or left obstructive CHD. NH-Black, Hispanics and NH-White infants had similar rates of conotruncal defects, but for right obstructive CHDs, NH-Blacks had higher rates of tricuspid valve atresia/stenosis (PR = 1.53; 95% CI: 0.87, 2.69, $P > 0.002$) and pulmonary valve atresia/stenosis (PR = 1.68; 95% CI: 1.38, 2.05, $P < 0.002$). Among infants with left obstructive defects, aortic valve atresia/stenosis was less frequent among NH-Black infants (PR = 0.46; 95% CI: 0.24, 0.89, $P < 0.002$) and Hispanic infants (PR = 0.53; 95% 0.28, 0.97) compared to NH-White infants. Among infants with septal defects, ventricular septal defect were less frequent among NH-Blacks (PR = 0.87; 95% CI: 0.79, 0.98, $P < 0.002$) and atrioventricular septal defects were less frequent among Hispanics (PR = 0.65, 95% CI: 0.44, 0.96; $P < 0.002$) relative to NH-Whites.

Distribution of Isolated, Multiple Congenital Heart Defects and Non-cardiac Defects

In our study, 44.5% of infants with a CHD had an isolated CHD, 26.8% had multiple heart defects and 28.7% had non-cardiac defects. We found few racial/ethnic differences in the distribution of isolated CHD, multiple heart, and CHD plus non-cardiac defects (Table 2). NH-Black and Hispanic infants were less likely to have multiple CHDs, CHDs plus non-cardiac defects, syndromes, or trisomies compared to NH-Whites (data not shown).

Prevalence of Isolated Congenital Heart Defects

As shown in Table 3, the overall prevalence of isolated heart defects was 36.23 per 10,000 live births for NH-Whites, 35.81 per 10,000 live births for NH-Blacks and 32.24 per 10,000 live births for Hispanics. There were no statistically significant racial/ethnic differences in overall rates of isolated CHDs. For specific types of CHDs, notable differences were among infants with right obstructive CHD; NH-Blacks had a higher rate of tricuspid valve atresia/stenosis (PR = 1.39; 95% CI: 0.32, 5.99, $P > 0.002$), and more than a two-fold increased rate of isolated pulmonary valve atresia/stenosis (PR = 2.33; 95% CI: 1.76, 3.10, $P < 0.002$) relative to NH-Whites. Among infants with septal defects, NH-Black infants were less likely to have isolated ventricular septal defects than NH-Whites (PR = 0.83; 95% CI: 0.72, 0.96, $P < 0.002$).

Prevalence of Multiple CHDs & CHD + Non-cardiac Defects

Compared to NH-Whites, Hispanics had prevalence rates of multiple heart defects 1.19 times as high (95% CI: 1.03, 1.38, $P < 0.002$) but NH-Blacks had rates similar to NH-Whites (PR = 0.95; 95% CI: 0.82, 1.12) (Table 4). The only racial/ethnic differences we observed in rates of multiple CHD were for ventricular septal defect in which Hispanics had a higher prevalence compared to NH-Whites (PR = 1.31; 95% CI: 1.10, 1.56, $P < 0.002$). We found no statistically significant racial/ethnic differences in rates, overall or for specific types, of CHD plus non-cardiac defects (data not shown).

Table 1 Distribution, prevalence, prevalence rate ratios and 95% simultaneous confidence intervals for congenital heart defects by maternal race/ethnicity, Florida Birth Defects Registry 1998–2003

Congenital heart defect[a]	Number			Percent			Prevalence rate[c]			Rate ratio[d,e]	
	NHW[b]	NHB[b]	Hispanic	NHW[b]	NHB[b]	Hispanic	NHW[b]	NHB[b]	Hispanic	NHB[b] (95% CI)	Hispanic (95% CI)
Common truncus	62	31	22	0.7	0.7	0.5	0.98 (0.75–1.26)	1.14 (0.78–1.62)	0.78 (0.49–1.18)	1.16 (0.60–2.26)	0.79 (0.37–1.66)
Transposition of great vessels	282	103	107	3.4	2.4	2.2	4.30 (4.00–5.03)	3.62 (3.10–4.61)	3.64 (3.10–4.57)	0.85 (0.60–1.21)	0.84 (0.60–1.20)
Tetralogy of Fallot	347	146	131	4.2	3.4	2.8	5.34 (4.94–6.12)	5.02 (4.55–6.33)	4.59 (3.87–5.49)	0.98 (0.73–1.32)	0.84 (0.61–1.15)
Tricuspid valve atresia/stenosis	73	48	33	0.9	1.2	0.7	1.11 (0.91–1.46)	1.74 (1.31–2.35)	1.10 (0.80–1.63)	1.53 (0.87–2.69)	1.01 (0.53–1.90)
Pulmonary valve atresia/ stenosis	575	415	260	6.9	9.9	5.3	8.78 (8.40–9.90)	14.73 (13.88–16.87)	8.91 (8.10–10.38)	1.68 (1.38–2.05)[f]	1.01 (0.80–1.27)
Ebstein's anomaly	40	7	17	0.5	0.1	0.3	0.64 (0.45–0.86)	0.22 (0.10–0.53)	0.53 (0.35–0.96)	0.41 (0.12–1.34)	0.95 (0.40–2.24)
Hypoplastic left heart syndrome	149	85	61	1.8	2.0	1.2	2.29 (2.00–2.78)	2.99 (2.51–3.88)	2.05 (1.65–2.77)	1.33 (0.88–2.01)	0.91 (0.57–1.45)
Aortic valve atresia/stenosis	127	25	30	1.5	0.6	0.6	1.95 (1.68–2.40)	0.89 (0.59–1.36)	1.03 (0.72–1.51)	0.46 (0.24–0.89)[f]	0.53 (0.28–0.97)[f]
Coarctation of the aorta	358	127	120	4.4	3.1	2.5	5.59 (5.11–6.30)	4.54 (3.91–5.58)	4.14 (3.52–5.07)	0.82 (0.60–1.13)	0.75 (0.54–1.03)
Ventricular septal defect	3081	1166	1461	37.3	27.5	30.1	47.64 (47.21–50.68)	40.94 (40.61–45.58)	50.16 (49.03–54.34)	0.87 (0.79–0.98)[f]	1.06 (0.96–1.16)
Atrioventricular septal defect	287	111	84	3.5	2.6	1.7	4.46 (4.05–5.12)	3.84 (3.37–4.93)	2.90 (2.37–3.68)	0.90 (0.64–1.27)	0.65 (0.54–0.95)[f]
Total	4982	2104	2266	100	100	100	79.11 (76.93–81.32)	77.67 (74.40–81.05)	80.09 (76.84–83.45)	0.98 (0.91–1.06)	1.01 (0.94–1.09)

Prevalence is per 10,000 live births

[a] Number of cases represented; infants may be represented in more than 1 category

[b] NHB = non-Hispanic Black; NHW = non-Hispanic White

[c] Prevalence rates calculated by number of cases of CHD divided by the number of live births during the study period

[d] Referent group = non-Hispanic Whites

[e] Rate ratios calculated by prevalence rate for NHB and Hispanic divided by the prevalence rate for NHW

[f] Confidence interval does not include 1

Table 2 Distribution of isolated, multiple and non-cardiac defects among infants with congenital heart defects (CHD) by maternal race/ethnicity

Congenital heart defect[a]	Isolated CHD						Multiple heart defects						CHD + non-cardiac defects						$P(X^2)$
	Number			Percent[c]			Number			Percent[c]			Number			Percent[c]			
	NHW[b]	NHB[b]	Hisp[b]	NHW[b]	NHB[b]	Hisp[b]	NHW[b]	NHB[b]	Hisp[b]	NHW[b]	NHB[b]	Hisp[b]	NHW[b]	NHB[b]	Hisp[b]	NHW[b]	NHB[b]	Hisp[b]	
Conotruncal defects																			
Common truncus	10	4	4	55.6	22.2	22.2	31	14	10	56.4	25.4	18.2	21	13	8	50.0	31.0	19.0	0.945
Transposition of the great vessels	31	9	10	62.0	18.0	20.0	186	76	81	54.2	22.2	23.6	63	18	16	65.7	18.2	16.2	0.307
Tetralogy of Fallot	99	50	34	54.1	27.3	18.6	130	49	47	57.5	21.7	20.8	118	47	50	54.9	21.9	23.3	0.560
Right obstructive defects																			
Tricuspid valve atresia/stenosis	10	6	3	52.6	31.6	15.8	50	32	27	45.9	29.4	24.8	13	10	3	50.0	38.5	11.5	0.592
Pulmonary valve atresia/stenosis	234	235	103	40.9	41.1	18.0	228	126	126	47.5	26.3	26.2	113	54	31	57.1	27.3	15.7	**0.000**
Ebstein's anomaly	17	2	2	81.0	9.5	9.5	14	4	12	46.7	13.3	40.0	9	1	3	69.2	7.7	23.1	0.128
Left obstructive defects																			
Hypoplastic left heart syndrome	51	22	14	58.6	25.3	16.1	66	48	34	44.6	32.4	23.0	32	15	13	53.3	25.0	21.7	0.298
Aortic valve atresia/stenosis	47	8	7	75.8	12.9	11.3	60	12	20	65.2	13.0	21.7	20	5	3	71.4	17.9	10.7	0.388
Coarctation of the aorta	91	26	27	63.2	18.1	18.8	172	69	63	56.7	22.7	20.7	95	32	30	60.5	20.4	19.1	0.722
Septal defects																			
Ventricular septal defects	1666	595	702	56.2	20.1	23.7	868	341	512	50.4	19.8	29.8	547	230	247	53.4	22.5	24.1	**0.000**
Atrioventricular septal defect	26	13	6	57.8	28.9	13.3	71	36	25	53.8	27.3	18.9	190	62	53	62.3	20.3	17.4	0.352
Total	2282	970	912	54.8	23.3	21.9	1287	531	688	51.4	21.2	27.4	1413	603	666	52.7	22.5	24.8	**0.000**

[a] Number of cases represented; infants may be represented in more than 1 category

[b] NHB = non-Hispanic Black; NHW = non-Hispanic White; Hisp = Hispanic

[c] Percentages do not add up to 100% due to rounding error

Bold values denotes the *P* values provided by STATA Software Program was *P* = 0.000

Table 3 Distribution, prevalence, prevalence rate ratios and 95% simultaneous confidence intervals for isolated congenital heart defects (CHD) by maternal race/ethnicity, Florida Birth Defects Registry, 1998–2003

Congenital heart defect	Number			Percent			Prevalence rate[b]			Rate ratio[c,d]	
	NHW[a]	NHB[a]	Hispanic	NHW[a]	NHB[a]	Hispanic	White[a] (95% CI)	Black[a] (95% CI)	Hispanic (95% CI)	Black[a] (95% CI)	Hispanic (95% CI)
Conotruncal defects											
Common truncus	10	4	4	0.17	0.12	0.12	0.16 (0.08–0.29)	0.15 (0.04–0.38)	0.14 (0.04–0.36)	0.93 (0.18–4.76	0.89 (0.17–.4.56)
Transposition of the great vessels	31	9	10	0.57	0.26	0.29	0.49 (0.33–0.70)	0.33 (0.15–0.63)	0.35 (0.17–0.65)	0.67 (.22–2.21)	0.72 (0.24–2.09)
Tetralogy of Fallot	99	50	34	1.78	1.44	1.00	1.57 (1.28–1.91)	1.85 (1.37–2.43)	1.20 (0.83–1.68)	1.17 (0.69–1.99)	0.76 (0.42–1.40)
Right obstructive defects											
Tricuspid valve atresia/ stenosis	10	6	3	0.18	0.18	0.09	0.16 (0.08–0.29)	0.22 (0.08–0.48)	0.11 (0.02–0.31)	1.39 (0.32–5.99)	0.67 (0.11–3.96)
Pulmonary valve atresia/ stenosis	234	235	103	4.16	6.71	2.91	3.72 (3.25–4.22)	8.68 (7.60–9.86)	3.64 (2.97–4.42)	2.33 (1.76–3.10)[e]	0.98 (0.68–1.41)
Ebstein's anomaly	17	2	2	0.31	0.06	0.03	0.27 (0.16–0.43)	0.07 (0.01–0.27)	0.07 (0.01–0.26)	0.27 (0.04–1.96)	0.26 (0.04–1.87)
Left obstructive defects											
Hypoplastic left heart syndrome	51	22	14	0.89	0.62	0.41	0.81 (0.60–1.06)	0.81 (0.50–1.23)	0.49 (0.27–0.83)	1.00 (0.47–2.16)	0.61 (0.25–1.50)
Aortic valve atresia/stenosis	47	8	7	0.85	0.24	0.21	0.75 (0.55–0.99)	0.30 (0.13–0.58)	0.25 (0.10–0.51)	0.40 (0.13–1.21)	0.353 (0.10–1.08)
Coarctation of the aorta	91	26	27	1.65	0.74	0.79	1.44 (1.16–1.77)	0.96 (0.62–1.41)	0.95 (0.63–1.39)	0.66 (0.34–1.30)	0.66 (0.34–1.28)
Septal defects											
Ventricular septal defect	1666	595	702	30.02	16.63	20.07	26.45 (25.20–27.75)	21.97 (20.24, 23.80)	24.81 (23.01, 26.72)	0.83 (0.72–0.96)[e]	0.94 (0.82–1.08)
Atrioventricular septal defect	26	13	6	0.65	0.29	0.18	0.41 (0.37–0.60)	0.48 (0.26–0.82)	0.21 (0.08–0.46)	1.16 (0.43–3.17)	0.51 (0.14–1.89)
Total	2282	970	912	100	100	100	36.23 (34.77–37.75)	35.81 (33.59, 38.13)	32.24 (30.18, 34.39)	0.99 (0.88–1.11)	0.89 (0.79–1.00)

Prevalence is per 10,000 live births

[a] NHB = non-Hispanic Black; NHW = non-Hispanic White

[b] Prevalence rates calculated by number of cases of CHD divided by the number of live births during the study period

[c] Referent group = NH-Whites

[d] Rate ratios calculated by prevalence rate for NHB and Hispanic divided by the prevalence rate for NHW

[e] Confidence interval does not include 1

Table 4 Distribution, prevalence, prevalence rate ratios and 95% simultaneous confidence intervals for multiple CHD by maternal race/ethnicity, Florida Birth Defects Registry, 1998–2003

Congenital heart defect[a]	Number			Percent			Prevalence rate[c]			Rate ratio[d,e]	
	NHW[b]	NHB[b]	Hispanic	NHW[b]	NHB[b]	Hispanic	NHW[b] (95% CI)	NHB[b] (95% CI)	Hispanic (95% CI)	NHB[b] (95% CI)	Hispanic (95% CI)
Conotruncal defects											
Common truncus	31	14	10	2.49	2.78	1.49	0.49 (0.33–0.70)	0.52 (0.28–0.87)	0.35 (0.17–0.65)	1.05 (0.40–2.73)	0.72 (0.25–2.09)
Transposition of the great vessels	186	76	81	14.22	14.48	11.48	2.95 (2.54–3.41)	2.81 (2.21, 3.51)	2.86 (2.27–3.56)	0.95 (0.63–1.44)	0.97 (0.65–1.46)
Tetralogy of Fallot	130	49	47	9.96	8.73	7.00	2.06 (1.72–2.45)	1.81 (1.34, 2.39)	1.66 (1.22–2.21)	0.88 (0.53–1.46)	0.80 (0.48–1.35)
Right obstructive defects											
Tricuspid valve atresia/ stenosis	50	32	27	3.78	6.15	3.87	0.79 (0.58–1.05)	1.18 (0.81–1.67)	0.95 (0.63–1.39)	1.49 (0.75–2.94)	1.20 (0.59–2.47)
Pulmonary valve atresia/ stenosis	228	126	126	17.59	23.41	18.33	3.62 (3.17–4.12)	4.65 (3.87–5.54)	4.45 (3.71–5.30)	1.28 (0.91–1.80)	1.23 (0.88–1.73)
Ebstein's anomaly	14	4	12	1.12	0.60	1.64	0.22 (0.12–0.37)	0.15 (0.04–0.38)	0.42 (0.22–0.74)	0.66 (0.14–3.21)	1.91 (0.61–6.01)
Left obstructive defects											
Hypoplastic left heart syndrome	66	48	34	5.14	9.13	4.62	1.05 (0.81–1.33)	1.77 (1.31–2.35)	1.20 (0.83–1.68)	1.69 (0.95–3.01)	1.15 (0.61–2.17)
Aortic valve atresia/stenosis	60	12	20	4.58	2.18	2.83	0.95 (0.73–1.23)	0.44 (0.23–0.77)	0.71 (0.43–1.09)	0.46 (0.18–1.19)	0.74 (0.34–1.61)
Coarctation of the aorta	172	69	63	13.57	13.29	9.09	2.73 (2.34–3.17)	2.55 (1.98–3.22)	2.23 (1.71–2.85)	0.93 (0.60–1.44)	0.82 (0.52–1.28)
Septal defects											
Ventricular septal defect	868	341	512	67.31	64.68	74.22	13.78 (12.88–14.73)	12.59 (11.29–14.00)	18.10 (16.56–19.73)	0.91 (0.75–1.11)	1.31 (1.10–1.56)[f]
Atrioventricular septal defect	71	36	25	5.54	6.94	3.73	1.13 (0.88–1.42)	1.33 (0.93–1.84)	0.88 (0.57–1.30)	1.18 (0.63–2.19)	0.78 (0.39–1.58)
Total	1287	531	688	100	100	100	20.44 (19.34–21.58)	19.60 (17.97–21.34)	24.32 (22.54–26.20)	0.95 (0.82–1.12)	1.19 (1.03–1.38)[f]

Prevalence is per 10,000 live births

[a] Number of cases represented; infants may be represented in more and 1 category

[b] NHB = non-Hispanic Black; NHW = non-Hispanic White

[c] Prevalence rates calculated by number of cases of CHD divided by the number of live births during the study period

[d] Referent group = NH-Whites

[e] Rate ratios calculated by prevalence rate for NHB and Hispanic divided by the prevalence rate for NHW

[f] Confidence interval does not include 1

Discussion

The intent of this investigation was to determine the prevalence of CHDs and specific types of CHDs for NH-White, NH-Black and Hispanic infants. We found that the prevalence of CHDs was similar for all racial/ethnic groups but varied for a few specific types of CHDs and by number of defects. Hispanics had the highest prevalence of CHDs overall and for infants with isolated and multiple heart defects, followed by NH-Blacks and NH-Whites. Unlike other studies which reported higher rates of conotruncal defects [3, 17] for White infants compared to Black infants, we found no statistically significant differences. Among infants with right obstructive CHDs, prior studies found a lower prevalence of Ebstein's anomaly among Blacks compared to NH-Whites [3] but a higher prevalence of tricuspid valve atresia/stenosis [18] and pulmonary valve atresia/stenosis for Blacks compared to NH-Whites [3, 18, 19]. We observed a non-statistically significant higher prevalence of tricuspid valve atresia/stenosis and a statistically significant higher prevalence of pulmonary valve atresia/stenosis among NH-Blacks compared to NH-Whites. The excess was even greater among NH-Blacks infants with isolated pulmonary valve atresia/stenosis. We also found a much lower prevalence of Ebstein's anomaly among NH-Blacks compared to NH-Whites but the difference was not statistically significant. Studies also reported Black–White differences in prevalence for infants with left obstructive CHDs. NH-Black infants are reported to have lower prevalence of hypoplastic left heart syndrome [19, 20], aortic valve atresia/stenosis [1, 3, 8, 18] and coarctation of the aorta [3, 8, 17, 21–23] relative to NH-Whites. In our study we only observed a statistically significant lower prevalence for NH-Black infants with aortic valve atresia/stenosis. Among infants with septal defects NH-Black infants are also reported to have lower prevalence of ventricular septal defect [24] and atrioventricular septal defect [3]. We observed a statistically significant lower prevalence of ventricular septal defect (VSD) overall and isolated VSD for NH-Blacks compared to NH-Whites.

NH-White-Hispanic differences in prevalence of CHDs have been less frequently researched. Prior studies report lower prevalence among Hispanic infants with tetralogy of Fallot [9], coarctation of the aorta [8, 22, 23] and ventricular septal defect [24] relative to NH-White infants. We did not observe a statistically significant lower prevalence of tetralogy of Fallot and coarctation of the aorta but did observe a statistically significant lower prevalence of aortic valve atresia/stenosis and atrioventricular septal defect for Hispanics compared to NH-Whites. We also observed a higher prevalence of Hispanic infants with VSD plus multiple heart defects compared to NH-White infants.

There are several potential explanations for our findings. First, the racial/ethnic differences we observed may be the result of differential loss of CHD-affected pregnancies during the gestational period rather than true differences in the incidence of CHDs. Our study estimated "prevalence at live birth" rather than CHD incidence since CHD incidence is a complex phenomenon affected by spontaneous miscarriages, fetal deaths, and elective terminations. Racial/ethnic differences in loss of pregnancies affected by CHD may cause differences in prevalence at live birth. To our knowledge, there is no information on racial/ethnic differences in rates of spontaneous miscarriages or fetal deaths for CHD-affected pregnancies, thus it is unknown if these losses affected our results. Elective termination rates are largely dependent upon prenatal diagnosis of CHD [25]. Notwithstanding improvements in prenatal detection of CHD since the 1980s, prenatal diagnosis of CHD remains challenging, e.g., infants with multiple defects are more likely to be diagnosed than infants with isolated CHD, and population-based estimates of prenatal diagnosis of CHD range from 31.7 to 57.0% [25–27]. Although NH-Black and Hispanic infants are less likely to have their CHD detected prenatally [28], there appears to be no differences in rates of elective terminations of CHD-affected pregnancies between NH-Blacks and NH-Whites [1].

Second, our findings may be due to racial/ethnic differences in CHD diagnosis after birth. Studies show racial/ethnic disparities in access to pediatric care and treatment received when care is obtained [29–31], revealing that Black children may be less likely to have their CHD diagnosed early in infancy than White children. However, studies report no statistically significant differences between Blacks and Whites in the age at diagnosis of CHD [24] or age at surgical repair for infants with CHD [24, 32]. Thus a racial/ethnic differential in diagnosis of CHD does not explain our results. Another potential explanation for our findings is racial/ethnic differential ascertainment of CHD cases by the birth defects registry. The Florida Birth Defects Registry (FBDR) is a passive surveillance system that ascertains birth defects cases by merging Florida birth records with administrative databases. Thus, the FBDR suffers from under ascertainment of birth defects common to passive registries that rely on the linkage of secondary, administrative data sets for case identification.

Strengths and Limitations

Strengths of our study include our large sample size and ethnically diverse population. Few previously published research included data on Hispanics [8, 9, 24]. Unlike previous studies we adjusted our level of significance to account for multiple hypothesis testing; as a result, the

findings we present are very conservative. We also include data on race/ethnic-specific prevalence of specific types of CHDs by the number of defects; thus the current study confirms prior research and also contributes important information to an under-investigated area in the literature.

Despite these strengths, our study has some potential limitations. Compared to active surveillance systems, which ascertain cases from medical record abstraction, passive systems generally underestimate the number of infants with birth defects, particularly CHDs. Therefore it is likely that we have underestimated the true number of CHD cases in Florida. Another possible criticism is that birth defects registries which only ascertain cases of birth defects in the first year of life exclude infants who died shortly after birth without an autopsy, whose CHD is not diagnosed until after hospital discharge, or diagnosed later in childhood. A further limitation is that our data only include live births whereas other studies [1, 9] include data on stillbirths and terminations. Furthermore, the FBDR is a passive registry created by merging administrative datasets and the methodology used for data linkage is another potential limitation. It is possible that variables used to merge the databases (social security number, etc.) may be more likely missing for NH-Black and Hispanic infants. Consequently, fewer cases in these racial/ethnic groups would be matched in the linkage process and therefore, not included in the registry.

Implications

Notwithstanding the limitations, our study provides important information on racial/ethnic differences in specific types of CHDs. Further study will be essential to better understand the nature of these differences and their importance in clinical practice. This, in conjunction with study of families with multiple affected members, may be instrumental in identification of specific genes associated with CHDs. In turn, this may improve counseling and earlier identification of children with CHDs. Presently, it is clear that racial/ethnic background should not alter suspicion for the presence of CHDs either in the prenatal or postnatal diagnostic setting.

Conclusions

Taken together our results combined with prior research indicate few racial/ethnic differences in prevalence of CHDs but that those racial/ethnic differences in specific types of CHDs are consistent and may vary by number of defects. It unknown whether the differences observed is caused by differences in genetic polymorphisms or susceptibilities to environmental factors. Additional research is needed to determine if racial/ethnic differences in prevalence at live birth are due to differences in rates of CHD-affected pregnancies in spontaneous abortions, elective terminations or fetal deaths.

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