SN Comprehensive Clinical Medicine (2021) 3:2525–2532
https://doi.org/10.1007/s42399-021-01055-3

ORIGINAL PAPER

Association Between Maternal Race and the Occurrence of Cyanotic Congenital Heart Disease in the USA

Dandison Nat Ebeh[1] · **Shayesteh Jahanfar**[1]

Accepted: 31 August 2021 / Published online: 13 October 2021

Abstract

Overall mortality due to congenital heart disease in the United States declined between 1999 and 2017. However, disparities still exist in occurrence and mortality rates among specific racial/ethnic groups in the USA. This study aims to find the association between maternal race and the occurrence of Cyanotic Congenital Heart Disease (CCHD) in the USA. We carry out analysis on a secondary dataset (2017 Natality) obtained from the US Centers for Disease Control and Prevention. This was analyzed using descriptive, bivariate, and regression analysis. This cross-sectional study obtained sociodemographic information-maternal race, independent and confounder variables (explanatory variables), and the occurrence of Cyanotic Congenital Heart Disease (outcome variable) within the reporting States and U.S. territories. There was a report of 3,864,754 live birth out of 325,719,178 USA races and origin populations for the 2017 review year. A total number of 2130 CCHD birth was reported to have occurred out of the 3,8161,947 live births. The Chi-square test showed a statistically significant association between maternal race and the occurrence of CCHD. As well as, the following confounders mother's age, mother's nativity, combined gestation, pre-pregnancy diabetes, pre-pregnancy hypertension, month prenatal care began, smoking status, and Nutrition (WIC) all having a p-value of 0.01 each, respectively. Unadjusted odds ratios at 95 % CI of the association between maternal race and CCHD were 56 % higher among American Indian and Alaska Native women (95% CI 1.13-2.15) than the white racial group. In addition, the Odds were 13% (95% CI 0.78-0.98) and 46% (95% CI 0.43-0.66) less likely amongst Black and Asian or Pacific Islander, respectively. The odds were 402% markedly high for pre-pregnancy diabetes, 159% for pre-pregnancy hypertension, 38 % for smoking status, and 44%, 159%, and 42% respectively for prenatal care from 1st to 2nd months, 4th to 6th months, and 7th to the final month, when compared to no prenatal care. The odds of having a CCHD was 16% less likely for mothers on Nutrition (mothers on WIC) (95% CI 0.77-0.92), 19% (95% CI 0.73-0.90) for mothers age (under 35 years) category, and likewise for mothers born outside of the USA at 39% (95% CI 1.22-1.56). On Adjustment for confounders, the OR for this relationship was on the higher side for many of the variables. The odds of occurrence of CCHD were 59 % higher amongBlack (95% CI 1.27-2.0), 35% among AIAN (95 % CI 1.05-1.74), and 92 % among American Indian and Alaska Native (95 % CI 1.26-2.93) racial categories whencompared to Asian or Pacific Islander categories. The odds of having a CCHD was also elevated on adjustment for mothers born outside of the USA at 39% (95% CI 1.22-1.56), and at from the 7th to final month 94% (95% CI 1.38-2.73). However, the odds were insignificant in other categories and variables. These estimates suggest theoccurrence of a CCHD is associated with the analyzed independent predictor and confounder variables. An association exists between maternal race and the occurrence of cyanotic congenital heart disease in the USA. Further research in this area, may therefore help to diminish the occurrence, morbidity, and or mortality of CCHD in America and globally as well.

Keywords Association · Maternal race · Cyanotic congenital heart disease · USA

This article is part of the Topical Collection on *Medicine*

✉ Dandison Nat Ebeh
ebeh1dn@cmich.edu
https://www.cmich.edu

[1] Health Sciences Building, 2242, Central Michigan University, Mount Pleasant, MI 48859, USA

Introduction

According to the [1], an estimate of about 1 million children under the age of 18 and 1.4 million adults in the United States (USA) was living with a congenital heart defect (CHD). About 12% (289,000 people) were estimated to have

severe CHD. A study published on the American College of Cardiology (2020) website carried out by Lopez et al. (2016) revealed that overall mortality in the USA declined in a downward trend in the last 19 years between 1999 and 2017. But sadly, it concluded that disparity persists in occurrence and its mortality rate among specific racial and gender groups in the USA (Lopez, 2020).

Congenital heart disease (CHD) is said to occur as a result of a structural defect of the heart or great intrathoracic vessels that happens during fetal development (Galvis et al. 2020). Presently, known to be the most common type of congenital disability and the leading cause of death in children with congenital malformations. CHD is of two types, non-cyanotic CHD and cyanotic CHD (CCHD), also called critical congenital heart disease (CCHD) (Galvis et al., 2020). CCHD is additionally subclassified into 3 different types of lesions: right heart obstructive lesions, left heart obstructive lesions, and mixing lesions [2] & Segura et al., 2019 & Mohammad et al., 2019 & [15],as cited by Galvis, 2020). More females (1,260,000) have a mild margin than males (1,163,000) living with a CHD in the USA (Mathews & MacDorman, 2008, cited by Kotch (p.212)).

The World Health Organization [19] put forward that an estimated 303,000 newborns die within 4 weeks of life every year due to congenital anomalies globally. Twelve congenital anomalies are separately identified in the CDC 2017 public use file dataset: (1) anencephaly,(2) meningomyelocele/spina bifida; (3) cyanotic congenital heart disease; (4) congenital diaphragmatic hernia; (5) omphalocele; (6) gastroschises; (7) limb reduction defect; (8) cleft lip with or without cleft palate; (9) cleft palate alone; (10) Down syndrome; (11) suspected chromosomal disorder; and (12) hypospadias. The most common, severe congenital anomalies have been heart defects, neural tube defects, and Down syndrome. The highest mortality rate is seen in infants below 1 year of age. Disparities in mortality occurred with mortality rates greater in men than women, and in non-Hispanic blacks compared with non-Hispanic whites (Lopez et al., 2020).

The root etiology of CHD is mostly unknown and, for many cases, is multifactorial and a result of a combination web of environmental risk factors and background genetic predisposition (Lopez et al., 2020; [18]. According to WHO [19], it is often difficult to identify the exact cause and result from one or more genetic, infectious, nutritional, or environmental factors. CCHD is usually seen as isolated and sporadic cases and is also associated with a genetic syndrome. Approximately 15 to 20% of infants with CCHD are related to known chromosomal abnormalities,most of these are aneuploidies (trisomy 21, 13, and 18 and Turner syndrome).

CCHD environmental risk factors include maternal morbidities such as phenylketonuria and diabetes, maternal drug use or exposure to toxins, and viral infections during pregnancy [19]. Several congenital anomalies can be prevented through the adequate nutrient intake or use of folic acid or iodine and food fortification or supplementation, as well as adequate antenatal care [19]. At the moment, the USA does not track older affected children and adults with CHDs. It was imperative just as some researchers have used data from the CDC dataset to estimate the link between diabetes before pregnancy and all CHDs, including that of specific CHDs (Marelli et al. 2008, quoted by [1], to then add to the scientific works of literature by finding other causal association to the occurrence of specific CHDs (CCHD) in the USA. Thus, establishing these associated links can help policymakers and healthcare systems plan to meet the health needs of the growing population of adults with CCHDs and prevent its occurrence in children [1].

This work seeks to find, using data from the CDC 2017 public use file, the link between maternal race and the occurrence of CCHD in the USA and so to bring this association to the limelight.

Methods

Study Design

Secondary datasets were acquired from the Centers for Disease Control and Prevention 2017 Natality public use file. Cross-sectional observation of the racial distribution of the occurrence of CCHD among a total USA population of 325,719,178 of all races and origin was made for the reported year. The file made a report on a total of 3,864,754 birth record count in accruing from the 50 states, including the District of Columbia and United States territories. A total of 48 states and the District of Columbia (excluding South Carolina and Tennessee) reported information on the type of infertility treatment used, representing 96.4% of 2017 births.

Participants

Women of all racial groups who fell within the reporting states and US territories constituted the study population. This participants dataset of 2130 CCHD occurrence was derived from the 3,8161,947 birth record respondents. Women who had undergone natal care outside the reporting coverage were not reported in the file. Thus, they were not included in the study. Male partners were also excluded to eliminate duplication of responses.

Study Variables

The independent variable for the study was the maternal race, and this was obtained from a reported mother's race of six categories consisting of white (only), black (only),

American Indian or Alaska Native (AIAN) only, and Asian or PI only.

The dependent variable was the occurrence of CCHD. Other variables were added during the analysis to adjust for potential covariate and confounding effects. These cofounders include mother's age (under 35 years and above 35 to 54 years), marital status, payment method (Medicaid, private insurance, self-pay, others), hepatitis B infection, hepatitis C infection, gonorrhea infection, syphilis infection, chlamydia infection, use of assisted reproductive technology (ART), pre-pregnancy hypertension, pre-pregnancy diabetes, educational status, mother's nativity, month prenatal care began, smoking status, and nutrition (WIC).

The final confounding variables for the adjusted models were selected after performing a 2-stage process. First, a series of statistical tests were performed to assess frequency distribution and then checked for characteristics of a relationship with CCHD. Confounders that were significantly (p-value 0.01) associated with the occurrence of CCHD were considered in the next stage, involving binary logistic regression analysis for association correlation.

The list of potential confounders was further shrinked using multivariate logistic regression modeling and a backward elimination stepwise regression approach, keeping only those variables that were significant at a p-value 0.01.

Giving the large sample size (total race population from all races = 325,719,178, live birth N = 3,864,754, total birth occurrence of CCHD "n" = 2130, and having 48 out of 50 reporting states), statistical analysis was powerful enough to assess the association between the study variables.

Statistical Analysis

This was carried out using IBM SPSS Statistics for Windows, version 26 (IBM Corp., Armonk, NY, USA). Tests included chi-square tests for categorical variables, and both unadjusted (OR) and adjusted (AOR) odds ratios with 95% confidence intervals were calculated to approximate associations with variables having a p-value of less than 0.01. OR and AOR were deduced and checked for significance and variation between unadjusted and adjusted.

Result

Descriptive Analysis

A report of 3,864,754 live birth out of a total USA population of 325,719,178 of all races and origin was drawn from the dataset. A total number of 2130 CCHD birth were reported out of 3,8161,947 respondents to have occurred. Table 1 shows the overall frequency distribution for the explanatory variables, as well as for the dependent variable CCHD. A review of Table 1 shows those who responded "YES" to CCHD were 0.1% (2130), and "NO" was 99.9% (3,859,817). The independent variable maternal race had a racial frequency distribution of white 74.2%, black 17.0%, Asian or PI 7.7%, and AIAN 1.1%, respectively. The rest of the variables (confounders), mother's age, has its age distribution to be 82.4% (under 35 years) and 17.6% (35–54 years); marital status 59.9% married, 40.1% unmarried; educational status 67.6% (below University degree) and 32.4 (above University degree), mother's nativity 76.7% (born inside the USA) and 23.3% (born outside the USA), combined gestation 99% (over 37% week) and 0.1% (over 37 week): payment method having 42.9% Medicaid, 49.0% as private insurance, 42.7%, 4.2% self-paid, and 3.8% others; gonorrheal, syphilis, chlamydia, hepatitis B, and hepatitis C infections were seen to have a low prevalence of 0.3%, 0.1%, 1.8%, 0.2%, and 0.5%, respectively; use of ART (63.4%), pre-pregnancy diabetes (0.9%), pre-pregnancy hypertension (1.9), month prenatal care began 7.2% (1st to 3rd months), 16.5% (4th to 6th months), 4.5% (7th to final month), and 1.8% (no antenatal), smoking status 6.9%, and nutrition (WIC) 38.0%. Bivariate analysis using the chi-square test as displaced in Table 2 demonstrates a statistically significant association between the explanatory variables and the dependent variable—CCHD. Vis-à-vis maternal race, mother's age, mother's nativity, combined gestation, pre-pregnancy diabetes, pre-pregnancy hypertension, month prenatal care began, smoking status, and nutrition (WIC) all having a p-value of 0.01 each, respectively.

Regression Analysis

Unadjusted Regression

Table 3 shows the odds of having a CCHD based on each independent variable and confounders examined. The unadjusted odds ratios at 95% CI for the association maternal race and CCHD were 56% higher among AIAN than whites. However, it was lower and less likely in the other maternal races of the black at 13% (95% CI 0.78–0.98) and Asian or PI 46% (95% CI 0.43–0.66) comparing to white. The estimate was lower at 19% (95% CI 0.73–0.90) for mothers of age category (under 35 years), 39% (95% CI 1.22–1.56) for mothers' nativity status (born outside of the USA), and at 16% (95% CI 0.77–0.92) for mothers with nutrition (WIC) status. The odds were 402% markedly high for pre-pregnancy diabetes, 159% for pre-pregnancy hypertension, 38% for smoking status, and 44%, 159%, and 42% respectively for prenatal care from 1st to 2nd months, 4th to 6th months, and 7th to the final month, when compared to no prenatal care.

Table 1 Frequency distribution of variables (Natality Public Use file, CDC, 2017)

Variables	Frequency (percentage)
Cyanotic congenital heart disease (dependent variable)	
Yes	2130 (0.1)
No	3,859,817 (99.9)
Maternal race (independent variable)	
Race	
White	2,866,011 (74.2)
Black	658,760 (17.0)
AIAN*	41,938 (1.1)
Asian or PI**	298,045 (7.7)
Confounders	
Mother's age	
Under 35 years	3,183,939 (82.4)
Above 35 years	680,815 (17.6)
Marital status	
Married	2,032,203 (59.9)
Unmarried	1,359,731 (40.1)
Educational status	
Below University degree	2,579,555 (67.6)
Above University degree	1,235,412 (32.4)
Mother's nativity	
Born in USA	2,959,569 (76.7)
Born outside USA	897,484 (23.3)
Combined gestation	
Under 37 weeks	3,861,926 (99.9)
37 weeks over	2828 (0.1)
Payment method	
Medicaid	1,648,323 (42.9)
Private insurance	1,882,268 (49.0)
Self-pay	163,242 (4.2)
Other	147,445 (3.8)
Gonorrhea infection	
Yes	11,336 (0.3)
No	3,843,319 (99.7)
Syphilis infection	
Yes	3898 (0.1)
No	3,850,757 (99.9)
Chlamydia infection	
Yes	70,580 (1.8)
No	3,784,075 (98.2)
Hepatitis B infection	
Yes	8994 (0.2)
No	3,845,661 (99.8)
Hepatitis C	
Yes	18,097 (0.5)
No	3,836,558 (99.5)
Use of ART	
Yes	42,846 (63.4)
No	24,708 (36.6)
Pre-pregnancy diabetes	
Yes	35,365 (0.9)
No	3,825,603 (99.1)
Pre-pregnancy hypertension	
Yes	73,072 (1.9)
No	3,787,896 (98.1)
Month prenatal care began	
1 to 3rd month	2,907,955 (77.2)
4 to 6th month	620,205 (16.5)
7th to final month	171,030 (4.5)
No prenatal care	66,824 (1.8)
Smoking status	
Yes	264,975 (6.9)
No	3,580,938 (93.1)
Nutrition (WIC)	
Yes	1,453,053 (38.0)
No	2,366,493 (62.0)

*American Indians and Alaska Native

**Asian or Pacific Islander

Adjusted Regression

On adjustment for confounders, the OR for this relationship was on the higher side for many of the variables. The odds of occurrence of CCHD were 59% higher among black (95% CI 1.27–2.0), 35% among AIAN (95% CI 1.05–1.74), and 92% among Asian or PI (95% CI 1.26–2.93) when compared to the white as the reference category. The odds of having a CCHD also showed significant elevated estimates values on adjustment for mothers born outside of the USA at 39% (95% CI 1.22–1.56), and at 94% (1.38–2.73) for prenatal care started from the 7th to the final months of pregnancy. However, the odds were less likely in other categories from 1st to 2nd months at 29% (95% CI 0.52–0.97), and 4th to 6th months at 92% (95% CI 0.78–1.52). These results suggest the likelihood of having a CCHD is associated with analyzed explanatory variables—maternal race and confounders.

All explanatory variables reflected significant variation in values on adjustment with the exception of maternal age, which showed no changes. On adjustment of mother's nativity, categories show OR increment of 0.30 (0.69–0.39). Pre-pregnancy diabetes shows a 4.99 OR decrease (5.2–0.21). Pre-pregnancy hypertension showed a 2.09 decrease (2.59–0.50), smoking status showed 0.57 (1.38–0.81) OR decrease, and nutrition (WIC) showed 0.02 OR decrease (0.84–0.82). The same decrease was observed with the month prenatal care began category.

Table 2 Association between maternal race and the occurrence of cyanotic congenital heart disease in the USA. Chi-square test statistical analysis, result of maternal race (independent variable), confounders variables and cyanotic congenital heart disease (dependent variable) (Natality Public Use file, CDC, 2017). $N = 3{,}864{,}754$ live birth, maternal population of all race and origin = 325,719,178. $n = 2130$ CCHD birth were reported out of 3,8161,947 respondents

Variables	CCHD (YES)	CCHD (NO)	*P*-value
Maternal race (independent variable)	1665 (78.2)	2,860,793 (74.2)	0.01
White	334 (15.7)	657,326 (17.0)	
Black	38 (1.8)	41,858 (1.1)	
AIAN*	93 (4.4)	297,710 (7.7)	
Asian or PI**			
Confounders			
Mother's age	1685 (79.1)	3,178,232 (82.4)	0.01
Under 35 years	445 (20.9)	679,455 (17.6)	
35 to 54 years			
Marital status	1274 (61.1)	2,028,220 (59.9)	0.27
Married	811 (38.9)	1,356,734 (40.1)	
Unmarried			
Educational status	1464 (69.5)	2,574,948 (67.6)	0.06
Below University degree	641 (30.5)	1,233,655 (32.4)	
Above University degree			
Mother's nativity	1749 (82.6)	2,953,934 (76.7)	0.01
Born in the USA (50 US states)	368 (17.4)	896,157 (23.3)	
Born outside the USA (includes possessions)			
Combined gestation	11,354 (66.6)	5704 (33.4)	0.01
Under 37 weeks	31,481 (62.4)	18,999 (37.6)	
37 weeks over			
Payment method	927 (43.9)	1,645,391 (42.9)	0.35
Medicaid	1034.6 (48.8)	1,879,609.4 (49.0)	
Private insurance	89.7 (3.5)	162,937.3 (4.2)	
Self-pay	81.0 (3.8)	147,188.0 (3.8)	
Other			
Gonorrhea infection	6 (0.3)	11,319 (0.3)	0.93
Yes	2116 (99.7)	3,837,694 (99.7)	
No			
Syphilis infection	1 (0.0)	3892 (0.1)	0.43
Yes	2121 (100)	3,845,121 (99.9)	
No			
Chlamydia infection	36 (1.7)	70,474 (1.8)	0.64
Yes	2086 (98.3)	3,778,539 (98.2)	
No			
Hepatitis B	4 (0.2)	8978 (0.2)	0.67
Yes	2118 (99.8)	3,840,035 (99.8)	
No			
Hepatitis C	14 (0.7)	18,056 (0.5)	0.20
Yes	2108 (99.3)	3,830,957 (99.5)	
No			
Use of ART	33 (57.9)	42,776 (63.4)	0.39
Yes	24 (42.1)	24,652 (36.6)	
No			
Pre-pregnancy diabetes	97 (4.6)	35,198 (0.9)	0.01
Yes	2029 (95.4)	3,819,835 (99.1)	
No			
Pre-pregnancy hypertension	101 (4.8)	72,863 (1.9)	0.01
Yes	2025 (95.2)	3,782,170 (98.1)	
No			
Month prenatal care began	1350 (67.1)	2,903,961 (77.2)	0.01
1 to 3rd month	414 (20.6)	619,167 (16.5)	
4 to 6th month	205 (10.2)	170,620 (4.5)	
7th to final month	44 (2.2)	66,596 (1.8)	
No prenatal care			
Smoking status	196 (9.3)	264,329 (6.9)	0.01
Yes	1919 (90.7)	3,574,788 (93.1)	
No			
Nutrition (WIC)	708 (34.1)	1,450,583 (38.0)	0.01
Yes	1370 (65.9)	2,362,729 (62.0)	
No			

*American Indians and Alaska Native

**Asian or Pacific Islander

Table 3 Association between maternal race and the occurrence of cyanotic congenital heart disease in the USA. Binary logistic regression result of maternal race (independent variable), confounders variables and CCHD (dependent variable) (Natality Public Use file, CDC, 2017). $N = 3,864,754$ live birth, maternal population of all race and origin = 325,719,178. $n = 2130$ CCHD birth were reported out of 3,8161,947 respondents

Variables	Unadjusted odd ratio	Adjusted odd ratio
Maternal race (independent variable)		
White	1	1
Black	0.87 (0.78–0.98)	1.86 (1.51–2.30)
AIAN*	1.56 (1.13–2.15)	1.63 (1.30–2.05)
Asian or PI**	0.54 (0.43–0.66)	2.91 (1.99–4.24)
Confounders		
Mother's age		
Under 35 years	0.81 (0.73–0.90)	0.81 (0.73–0.90)
35 to 54 years	1	1
Mother's nativity		
Born in the USA (50 US states)	1	1
Born outside the USA (includes possessions)	0.69 (0.62–0.78)	1.44 (1.29–1.61)
Pre-pregnancy diabetes		
Yes	5.2 (4.2–6.3)	0.21 (0.17–1.26)
No	1	1
Pre-pregnancy hypertension		
Yes	2.59 (2.12–3.16)	0.50 (0.40–0.62)
No	1	1
Month prenatal care began		
1 to 3rd month	1.44 (1.29–1.60)	0.71 (0.52–0.97)
4 to 6th month	2.59 (2.23–2.99)	1.08 (0.78–1.50)
7th to final month	1.42 (1.05–1.91)	1.94 (1.38–2.73)
No prenatal care	1	1
Smoking status		
Yes	1.38 (1.92–1.60)	0.81 (0.73–1.01)
No	1	1
Nutrition (WIC)		
Yes	0.84 (0.77–0.92)	0.82 (0.74–0.90)
No	1	1

*American Indian or Alaska Native

**Asian or Pacific Islander

Discussion

CHD affects 8 to 9 per 1000 live births, and about 25% of this cardiovascular malformation is considered CCHD (Lopez et al., 2016). In an affected parent or following the birth of a child with CHD, CHD incidence increases by 2 to 6% for a second pregnancy. Tetralogy of Fallot (TOF) is the most common CCHD (5% of all CCHD). Transposition of the great arteries (TGA) is the second most common CCHD (approximately 2% of all CCHD), and it is the most common CCHD manifesting in the first week after birth. It is estimated that 35% of infant deaths due to congenital malformations are related to cardiovascular anomalies.

According to Gong et al. [5], CHD continues to represent a growing burden of illness among US adults. It was seen to cause a significant decrement in employment, lifetime earnings, life expectancy, and a concomitant increase in medical spending for affected patients. On top of this, it was also found that cancer, lung disease, and severe mental distress were more common among the cohort of CHD patients when compared to healthy individuals in the study. CHD also causes a serious impact on pregnancy (maternal and fetal) outcomes, as more women with surgically corrected heart conditions reach childbearing age [17]. In the same vein, Opotowsky et al. [12] in their study put forward that women were at a markedly increased risk of adverse cardiovascular events and death during admission for delivery. The prenatal diagnosis rate for critical CHD was also found to be poor for rural dwellers or those living in impoverished communities (Hills et al., 2015). Furthermore, Niwa et al. (2004) in a research survey of specialized tertiary care hospitals of six participating facilities in North America and Europe for adults with CHD concluded that there appears to be a significant shortfall in tertiary care provision for the adult with CHD. The disparity in access to healthcare continues to pose a superimposed burden reflective on both increase in

occurrence, morbidity, and mortality figures as well as the disparity in mortality rate [20],Lopez et al., 2020).

The data presented in this study suggest that maternal race is strongly associated with CCHD in the USA. This was also obvious when controlled for confounders. A total number of 2130 CCHD was reported from the 3,864,754 live birth of all maternal races in the USA in the year under review. Bivariate analysis using the chi-square test, as shown in table, revealed a statistically significant association between each of the independent variables (maternal race) and the outcome variable (CCHD) at a p-value of < 0.01. This was significant in most instances for the other exploratory variables following the binary logistic regression analysis. The odds were higher for AIAN but less likely among black and Asian or PI racial categories when compared to white. However, on adjustment, it was seen higher for all the racial subcategories (black, AIAN, American Indian and Alaska Native) racial subcategories comparing to white.

This finding is unique because it points to a disparity that was reinforced by the other explanatory variables serving as confounders and it suggests a possible likelihood of confounders accounting for its occurrences in other races compared to the white race. Mostly through a combination of socioeconomic status and obstetrics and gynecological conditions (explanatory variables) affecting access or indication for antennal care. Socioeconomic barriers likely heightened or limit minority women from utilizing antenatal care due to lack of access, affordability, or social acceptance in their communities.

Even though the root etiology of CHD is mostly unknown, Lopez et al. (2020) and Bom et al. [18] in their studies have stated that for many cases, its occurrence is multifactorial and a result of a combination web of environmental risk factors and background genetic predisposition. Giorgione et al. [4], in a systematic review and meta-analysis work, concluded that pregnancy conceived through ART (IVF/ICSI) interventions is at a high risk of developing CHD when compared with those conceived spontaneously. However, Giorgione et al. [4] further asserted that this finding deserves further investigation due to the heterogeneity of both ART procedures and cardiac defects. Ebeh and Jahanfar [3] in a recent work found an association between maternal race and the use of ART in the USA. Thus, requiring further research in this direction to explore and elucidate which race category or ART procedure stands at greater risk for CHD occurrence, as such representing a benchmark opportunity for risk reduction in IVF procedures. Radke et al. [14] also recently raised a new dimension of concern of the high-risk COVID-19 to adults with congenital heart disease in their study that aims to give an overview of relevant data and pragmatic approach to CCHD prevention and management. This also representing implications on in-utero and pediatrics patients with a CCHD.

Thus, to knowledge, this study is the first to look at the association between a maternal race and the occurrence of CCHD to provide useful dimensions to care for an individual patient. This may help mitigate the various barriers that may be unevenly confounding to maternal race and the occurrence of CCHD. Therefore, the data used adds further credence that maternal race may be a genuinely independent predictor of use and success, given the national sample size of the dataset.

Missing data values were accounted for and clean up using standard assigned numbers. Again, confounding variables not meeting significance were eliminated on additional analysis in the study. An effort by the CDC through its surveillance and Disease Tracking System should be sustained, through its funding and coordination of the Metropolitan Atlanta Congenital Defects Program (MACDP), Congenital Heart Defects Surveillance across Time And Regions (CHD STAR) project, population-based state tracking programs, research, collaboration, partnership with March of Dimes surveyed adults with CHDs to assess their health, social and educational status, and quality of life (CH STRONG-Congenital Health Survey To Recognize Outcomes, Needs, and well-being), and provision of Technical Assistance to the Congenital Heart Public Health Consortium [1].

Conclusion

The study finds an association between maternal race and the occurrence of CCHD using a nationally representative sample, as reported in the 2017 CDC Natality Public Use File. Further research in this area may help reduce the occurrence, morbidity, and mortality associated with CCHD in America and globally as well.

Acknowledgements The authors acknowledge that this work arose from academic research carried out at Central Michigan University, USA. The authors express their gratitude to the Central Michigan University Department of Public Health, the Center for Disease Control and Prevention for making the dataset available for free online access, as well as the authors of cited references.

Author Contribution Both authors have contributed equally to the study.

Data Availability Data was accessed from the CDC free access file in SPSS format. Available from https://www.cdc.gov/nchs/data_access/vitalstatsonline.htm and https://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/DVS/natality/UserGuide2017.pdf.

Code Availability CDC Code book User guide to the 2017 Natality Public use file was accessed from https://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/DVS/natality/UserGuide2017.pdf.

Declarations

Ethics Approval Not applicable.

Informed Consent Not applicable.

Consent for Publication Both authors consent to publication.

Conflict of Interest The authors declare no competing interests.

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