HHS Public Access

Author manuscript

Birth Defects Res. Author manuscript; available in PMC 2022 March 11.

Published in final edited form as:

Birth Defects Res. 2022 January 15; 114(2): 45–56. doi:10.1002/bdr2.1980.

Prevalence of critical congenital heart defects and selected co-occurring congenital anomalies, 2014–2018: A U.S. population-based study

Erin Bugenske Stallings[1], **Jennifer L. Isenburg**[1], **Deepa Aggarwal**[2], **Philip J. Lupo**[3], **Matthew E. Oster**[1], **Hanna Shephard**[4,5], **Rebecca F. Liberman**[4], **Russell S. Kirby**[6], **Eirini Nestoridi**[4], **Brenda Hansen**[2], **Xiaoyi Shan**[7], **Maria Luisa Navarro Sanchez**[8], **Aubree Boyce**[9], **Dominique Heinke**[4] **National Birth Defects Prevention Network**

[1]National Center on Birth Defects and Developmental Disabilities, Centers for Disease Control and Prevention, Atlanta, Georgia, USA

[2]California Birth Defects Monitoring Program, Genetic Disease Screening Program, California Department of Public Health, California, USA

[3]Department of Pediatrics, Section of Hematology-Oncology, Baylor College of Medicine, Houston, Texas, USA

[4]Center for Birth Defects Research and Prevention, Massachusetts Department of Public Health, Boston, Massachusetts, USA

[5]Council of State and Territorial Epidemiologists, Atlanta, Georgia, USA

[6]College of Public Health, University of South Florida, Tampa, Florida, USA

[7]Arkansas Reproductive Health Monitoring System, Arkansas Children's Research Institute, Little Rock, Arkansas, USA

[8]Birth Defects Epidemiology and Surveillance, Texas Department of State Health Services, Houston, Texas, USA

[9]Utah Birth Defect Network, Utah Department of Health, Salt Lake City, Utah, USA

Abstract

Background: Critical congenital heart defects (CCHDs) are one of the most common types of birth defects and can lead to significant morbidity and mortality along with surgical or catheter interventions within the first year of life. This report updates previously published estimates

Correspondence: Erin Bugenske Stallings, Centers for Disease Control and Prevention, National Center on Birth Defects and Developmental Disabilities, 4770 Buford Highway, MS: S106-3, Atlanta, GA 30341-3717. icw6@cdc.gov.

AUTHOR CONTRIBUTIONS

Deepa Aggarwal, Hanna Shephard, Xiaoyi Shan, Maria Luisa Navarro Sanchez, and Aubree Boyce drafted the introduction. Erin B. Stallings drafted the methods, results, and discussion sections. Dominique Heinke supervised the project and contributed to the discussion section. Jennifer L. Isenburg and Erin B. Stallings performed all analyses. Jennifer L. Isenburg created all figures and tables. All authors provided meaningful contributions to the project plan and paper revisions. All authors reviewed the manuscript.

of CCHD prevalence with the latest population-based surveillance data from 19 birth defect surveillance programs.

Methods: The U.S. population-based surveillance programs submitted data on identified cases of 12 CCHDs and co-occurring cardiovascular and chromosomal birth defects from 2014 to 2018. We estimated prevalence by program type and maternal and infant characteristics. Among nine programs with active case ascertainment that collect more than live births, we estimated the percentage of co-occurring cardiovascular and chromosomal birth defects for the 12 CCHDs.

Results: We identified 18,587 cases of CCHD among all participating programs. Overall CCHD prevalence was 19.6 per 10,000 live births among all 19 programs and 20.2 per 10,000 live births among active programs. Among maternal racial/ethnic groups, infants/fetuses born to American Indian/Alaska Native mothers showed the highest overall prevalence for all CCHDs (28.3 per 10,000) along with eight of the 12 individual CCHDs. Among 7,726 infants/fetuses with CCHD from active case ascertainment programs, 15.8% had at least one co-occurring chromosomal birth defect.

Conclusion: Our study provides prevalence estimates for CCHDs by maternal and infant characteristics along with co-occurrence with cardiovascular and chromosomal birth defects among infants/fetuses with CCHD using one of the largest and most recent cohorts since the implementation of widespread CCHD screening. These data can provide a basis for future research to better understand risk factors for these defects.

1 | INTRODUCTION

Congenital heart defects (CHDs) are the most common type of birth defects, affecting one in 110 births in the United States (U.S.) (Mai et al., 2012; Reller, Strickland, Riehle-Colarusso, Mahle, & Correa, 2008). Critical congenital heart defects (CCHDs) comprise approximately 25% of CHDs and can lead to significant morbidity and mortality, requiring surgical or catheter intervention within the first year of life (Mahle et al., 2009). When compared to infants with noncritical CHDs, infants with CCHDs have a lower first year survival (77.2 vs. 91.7%) (Pace et al., 2018). A delayed diagnosis (after birth hospital discharge) may lead to poorer outcomes, including increased morbidity and mortality (Mahle et al., 2009). Consequently, the U.S. Department of Health and Human Services recommended screening newborns for CCHDs using pulse oximetry in 2011, with all states adopting screening by July 2018 (Martin et al., 2020).

The 12 most widely recognized and monitored CCHDs are coarctation of the aorta, common truncus (also known as truncus arteriosus), dextro-transposition of the great arteries (d-TGA), double outlet right ventricle (DORV), Ebstein anomaly, hypoplastic left heart syndrome (HLHS), interrupted aortic arch (IAA), pulmonary valve atresia, single ventricle, tetralogy of Fallot (TOF), total anomalous pulmonary venous connection (TAPVC), and tricuspid valve atresia (Mai et al., 2019). Prevalence estimates of CCHD in the U.S. range from 15.6 to 19.9 cases per 10,000 live births (Mai et al., 2019; Oster et al., 2013; Reller et al., 2008). These CCHDs are also the primary targets of CCHD screening using pulse oximetry (Oster et al., 2016).

While national and state-specific prevalence estimates and risk factors are well documented in the literature for CHDs, there have been fewer population-based studies of CCHDs. In 2012, the National Birth Defects Prevention Network (NBDPN) published a brief report on state-based prevalence and variability estimates of seven CCHDs based on population-based birth defects surveillance data from 2005 to 2009, prior to the widespread implementation of newborn CCHD screening (Mai et al., 2012). The objective of this study is to update these estimates with the latest population-based surveillance data from 19 participating birth defect surveillance programs. In addition, we further explore CCHD prevalence by maternal demographics and examine co-occurring cardiovascular and chromosomal congenital anomalies.

2 | METHODS

As a special call for data for the NBDPN, state-based and territorial birth defects surveillance programs were invited to report expanded data on infants/fetuses diagnosed with CCHDs. The call for data was open to programs using passive or active case ascertainment methods. Active case ascertainment methods include the review of discharge diagnostic codes and hospital-specific case lists from obstetrical, neonatal, surgical, and pathology services. Following initial identification of cases, medical records are abstracted from hospitals and other sources (e.g., genetics laboratories), which are then reviewed to confirm the report and ensure accurate defect classification. Passive case ascertainment relies on reporting by physicians or hospitals, or on linkage of existing administrative health data sources, such as hospital discharge and claims data, to identify cases. Some passive programs also conduct follow-up medical records review.

We requested information on infants/fetuses diagnosed with the following 12 CCHDs: coarctation of the aorta, common truncus, d-TGA, DORV, Ebstein anomaly, HLHS, IAA, pulmonary valve atresia, single ventricle, TOF, TAPVC, and tricuspid valve atresia. Surveillance programs identified these cases using the diagnosis guidelines outlined in Table 1 based on diagnostic codes from the International Classification of Diseases, ninth revision, Clinical Modification (ICD-9-CM), International Classification of Diseases, 10th revision, Clinical Modification (ICD-10-CM), and Centers for Disease Control and Prevention/British Pediatric Association (CDC/BPA) coding systems (Table 1). Cases that were reported with TOF and any of its components (ventricular septal defect [VSD], pulmonary stenosis, overriding aorta, right ventricular hypertrophy) were counted only as TOF and not as any of the component defects. Programs were asked to submit data on any co-occurring birth defects in the cardiovascular (ICD-9-CM/BPA 745–747 and ICD-10-CM Q20–Q28) and chromosomal (ICD-9-CM/BPA 758 and ICD-10-CM Q90–Q99) systems collected for these infants and fetuses, including major and minor defects. We also requested case-level information by year of birth, maternal race/ethnicity, maternal age at delivery, infant sex, pregnancy outcome, birth weight, and gestational age at delivery. Data were submitted by birth defects surveillance programs to the Centers for Disease Control and Prevention (CDC) for cleaning and analysis.

2.1 | Analyses

We estimated the prevalence of each of the collected CCHDs overall and stratified by case ascertainment method, maternal race/ethnicity, maternal age, and infant sex. We report prevalence estimates as the number of infants and fetuses with each CCHD per 10,000 live births. Those with more than one CCHD are included in the counts for each of their defects. We limited analyses of co-occurring birth defects to programs with active case ascertainment methodology that collected pregnancy outcomes beyond live births (including stillbirth, termination, and/or unspecified nonlive birth). We also limited our co-occurrence analyses to infants and fetuses with a gestational age ≥20 weeks at delivery or pregnancy end; for those missing data on gestational age, we required a birth weight of ≥350 g, whereas those missing both gestational age and birth weight were excluded from analysis.

Percent of co-occurring defects is reported as the number of infants and fetuses with the defect per 100 infants with any CCHD or specific CCHD. Estimates were not calculated where the NBDPN case definition stipulates that the two birth defects cannot be reported together or where one condition is considered part of another, as noted for TOF above. We used 95% confidence intervals (CIs) calculated by the exact Poisson methodology for prevalence estimates and exact binomial methodology for percentages (Daly, 1992). Data analysis was performed using SAS Version 9.4 (SAS Institute, Cary, NC). This activity was reviewed by CDC, deemed public health surveillance, and was conducted consistent with applicable federal law and CDC policy.[1]

3 | RESULTS

We obtained data on infants and fetuses with CCHDs from 19 U.S. state-based and territorial birth defects surveillance programs. These programs covered 9,469,325 total live births from 2014 to 2018. Figure 1 presents the variability in prevalence estimates for the included surveillance programs. Table 2 presents counts, prevalence (per 10,000 live births), and 95% CIs by case-finding methodology, maternal race/ethnicity, maternal age, and infant sex. For the 12 targeted CCHDs, the estimated prevalence (per 10,000 live births) ranged from 0.6 (95% CI 0.5–0.6) for common truncus to 5.8 (95% CI 5.6–5.9) for coarctation of aorta. The overall prevalence for any of the targeted 12 CCHDs was 19.6 (95% CI 19.3–19.9) per 10,000 live births (Table 2).

Overall prevalence for all targeted CCHDs was significantly higher among active surveillance programs compared to passive surveillance programs (20.1 [95% CI 19.7–20.6] vs. 19.2 [95% CI 18.8–19.6] per 10,000 live births, respectively), but this did not hold true among all individual CCHDs. Active surveillance programs reported higher prevalences of d-TGA, pulmonary valve atresia, and TAPVC, while passive surveillance programs reported higher prevalences of coarctation of the aorta, HLHS, IAA, and single ventricle. Prevalence did not vary by the case ascertainment method for the other CCHDs. The variability of estimates by jurisdiction was largest for coarctation of the aorta and lowest for truncus arteriosus (Figure 1).

[1]See for example, C.F.R. part 46.102(1)(2), 21 C.F.R. part 56; 42 U.S.C. §241(d); 5 U.S.C. §552a; 44 U.S.C. §3,501 et. seq.

We present counts, prevalence (per 10,000 live births), and 95% CIs by case-finding methodology, maternal race/ethnicity, maternal age, and infant sex in Table 2. Among maternal racial/ethnic groups, infants/fetuses born to American Indian/Alaska Native mothers showed the highest overall prevalence for all CCHDs (28.3 per 10,000), as well as for coarctation of the aorta, common truncus, DORV, Ebstein anomaly, pulmonary valve atresia, TOF, TAPVC, and tricuspid valve atresia. Infants/fetuses born to white, non-Hispanic mothers showed similarly high prevalence to those born to American Indian/Alaska Native mothers for coarctation of the aorta. The lowest overall prevalence was among infants/fetuses born to Asian or Pacific Islander, non-Hispanic mothers, who also had the lowest prevalence for seven of the 12 examined CCHDs.

Overall prevalence for all targeted CCHDs was significantly higher for infants/fetuses born to mothers age 35 and above. This observation held true for three of the defects—coarctation of the aorta, DORV, and TOF—with the other defects showing similar prevalence for infants/fetuses born to both younger and older mothers.

Male infants/fetuses had a significantly higher overall prevalence for all targeted CCHDs. This held true for seven of the 12 targeted CCHDS—coarctation of the aorta, d-TGA, DORV, HLHS, single ventricle, TOF, and TAPVC—with the remaining five CCHDs showing similar prevalence for both male and female infants/fetuses.

Table 3 shows overall prevalence among all targeted CCHDs for nine surveillance systems who use active case-finding to monitor all pregnancy outcomes. Prevalence among maternal racial/ethnic groups, maternal age at delivery, and infant sex showed the same trends as our analysis of all reporting programs, with higher prevalence among infants/fetuses born to American Indian/Alaska Native mothers, older mothers (age 35+), and male infants/fetuses.

The percentage of cardiovascular and chromosomal birth defects which co-occurred among infants/fetuses with CCHD is presented in Table 4. Atrial septal defect (ASD) was the most frequently co-occurring cardiovascular defect among infants/fetuses with any CCHD (38.9%) and also the most frequently co-occurring cardiovascular defect with the following 10 specific CCHDs: coarctation of aorta (35.9%), d-TGA (47.0%), DORV (43.1%), Ebstein anomaly (37.5%), HLHS (41.2%), pulmonary valve atresia (38.5%), single ventricle (41.6%), TOF (32.3%), TAPVC (51.3%), and tricuspid valve atresia (47.5%). VSD was the most frequently co-occurring cardiovascular defect with common truncus (44.5%) and IAA (64.7%). VSD co-occurred at a comparatively high rate among all targeted conditions except TAPVC.

We identified 81 cases where pulmonary valve atresia was found to co-occur with tricuspid valve atresia, representing 14.6 and 20.7% of those cases, respectively. Among single ventricle cases, atrioventricular septal defect, d-TGA, and DORV co-occurred frequently. Coarctation of aorta co-occurred frequently with HLHS, representing 10.6 and 23.2% of their cases, respectively.

Among the 12 targeted CCHDs, IAA (30.5%), common truncus (26.1%), and TOF (22.9%) most frequently co-occurred with a congenital anomaly in the chromosomal range, while d-TGA co-occurred least frequently with any chromosomal anomaly (5.8%). Among the

five individual chromosomal birth defects examined in this analysis, deletion 22q11.2 comprised the largest proportion of cases with common truncus (13.7%), IAA (21.9%), and pulmonary valve atresia (9.5%). Trisomy 18 co-occurred most frequently with DORV (5.6%) and trisomy 21 (Down syndrome) co-occurred most frequently with TOF (8.6%). Turner syndrome and trisomy 13 were the least common of the included chromosomal disorders to co-occur with any of the CCHDs.

4 | DISCUSSION

Our study included over 18,500 infants/fetuses with CCHD from 19 U.S. population-based birth defect surveillance programs. These programs represent 48% of all U.S. live births in this period. We found the overall prevalence of CCHDs to be 19.6 per 10,000 live births. The prevalence of individual CCHDs ranged from 0.6 (common truncus) to 5.8 (coarctation of the aorta) per 10,000 live births. Our point estimates are in line with previous national estimates using a similar profile of surveillance programs (Mai et al., 2012, 2019). In general, the range of variability in our prevalence estimates is much smaller than previously measured in Mai et al. (2012). This may be an indication that case ascertainment for CCHDs has improved in recent years, possibly as a result of increased screening (Martin et al., 2020).

Our analysis supports the hypothesis that CCHD prevalence, like that for all CHDs, is associated with various maternal demographic factors. CCHDs were associated with advanced maternal age, especially for coarctation of the aorta, DORV, Ebstein anomaly, and TOF. We also observed higher prevalence in male infants/fetuses than in females. Additionally, our findings show a high prevalence of CCHDs among infants/fetuses born to American Indian/Alaska Native mothers. Previous reports by Aggarwal et al. (2015) and Canfield et al. (2014) show elevated prevalence in this group for limited individual CHDs and CCHDs, but this is the most complete analysis of CCHDs by maternal race/ethnicity to suggest this association with American Indian/Alaska Native mothers. This higher prevalence of CCHDs may be related to inequitable distributions of resources by race/ethnicity. Reduced access to nutritious diets, health care, and exposure to interpersonal racism may lead to a greater exposure to factors which increase birth defect risks, such as environmental toxins and certain maternal health conditions (Mitchell, Sangalang, Lechuga-Peña, Lopez, & Beccera, 2020). For example, Marengo et al. (2018) found a higher prevalence of diabetes among American Indian/Alaska Native mothers (8%) compared to white, non-Hispanic and Hispanic mothers (3.7 and 5%, respectively). In another recent paper, Tinker et al. (2020) reported strong associations between several CCHDs included in our analysis and maternal diabetes. Nonetheless, this is relatively a new finding and can be further explored in future analyses.

Co-occurring cardiovascular defects were common among those with CCHDs. Specifically, among CCHD cases reported by active surveillance programs, ASD (38.9%), and VSD (21.7%) were the most frequent co-occurring cardiovascular defects. Indeed, all CCHDs we examined had ASD, VSD, or both as the most commonly associated heart defects, with an ASD present in approximately half of all cases of d-TGA, IAA, TAPVC, and tricuspid atresia. The high prevalence of co-occurring septal defects among identified CCHD

cases is likely the result of two key processes: first, a common developmental pathway and, second, a strong survival advantage conferred by the septal defect (Mostefa-Kara, Houyel, & Bonnet, 2018). For example, while tricuspid atresia may co-occur at random with septal defects among embryos, those surviving to diagnosis are more likely to have a septal defect or other defect (e.g., d-TGA), which provides a bypass for deoxygenated blood around the absent tricuspid valve (Mostefa-Kara et al., 2018; Sumal, Kyriacou, & Mostafa, 2020). While the fetal circulatory pathways (i.e., foramen ovale and ductus arteriosus) help bypass obstructions to pulmonary circulation, in infants without an additional bypass from septal or other cardiac defects, the closure of these pathways after birth can lead to rapid cardiovascular collapse (Remien & Majmundar, 2021; Sumal et al., 2020). However, infants with such bypasses may seem normal after birth; it is these infants that pulse oximetry screening aims to capture so that interventions can begin before complications arise (Oster et al., 2016; Sumal et al., 2020).

From past reports, roughly 15% of CHDs are linked to chromosomal defects and syndromes (Hartman et al., 2011; Øyen et al., 2009), but there is much less data evaluating links between CCHDs and chromosomal defects. Our analysis found 15% of CCHDs co-occurred with a chromosomal defect and that IAA, common truncus, and TOF co-occurred most frequently with chromosomal defects ranging from 22 to 30%. Among these defects, the most commonly co-occurring chromosomal conditions were found to be deletion 22q11.2 and trisomy 21. This is consistent with previous reports finding that 75% of infants with deletion 22q11.2 co-occurred with CHDs and suggests that CCHDs may follow a similar association (Marino et al., 2001; Ryan et al., 1997). Although CHDs are common features of Turner syndrome and occur among nearly all infants/fetuses with trisomy 13, these chromosomal disorders made up the smallest proportion of CCHD cases (Cramer, Bartz, Simpson, & Zangwill, 2014; Kosiv, Gossett, Bai, & Collins, 2017). Trisomy 13 is the least prevalent of the examined chromosomal disorders, so the low proportion among CCHD cases is not unexpected (Mai et al., 2012). However, Turner syndrome is often diagnosed after the first year of life so co-occurrence with CCHDs in this population of infants/fetuses is likely underestimated (Apperley et al., 2018).

This report must be considered in the light of certain limitations. To increase the reliability of our data, we restricted our case definition to all birth outcomes with 20 weeks or more completed gestation. As a result, we know that we will have missed earlier fetal deaths and terminations. Variations in case ascertainment methodology and anomalies collected by the different state-based and territorial programs could contribute to variations in the quantity and range of co-occurring defects reported. We attempted to limit this by restricting our analyses of co-occurring defects to only include data from surveillance programs with active case-finding methodologies. In addition, our analysis is limited to specific cardiovascular and chromosomal anomalies commonly collected by the participating birth defects surveillance programs. Finally, although the included registries cover a large portion of U.S. births, they are not demographically representative of U.S. births.

5 | CONCLUSION

In one of the largest analyses of prevalence and co-occurrence in infants/fetuses with CCHDs since the implementation of widespread CCHD screening, we confirmed several previous associations and provided updated measures of prevalence by maternal and infant factors along with measures of co-occurrence with cardiovascular and chromosomal conditions. Given the significant morbidity and mortality associated with CCHDs, our findings may help guide future research into updated risk factors for CCHDs and, ultimately, improve diagnosis and surveillance strategies.

ACKNOWLEDGMENTS

We would like to thank the state programs and analysts/epidemiologists that collected and provided the data for this report. This was funded in part by National Institutes of Health, Grant/Award Number: R01CA24986701 (Lupo). This study/report was supported in part by an appointment to the Applied Epidemiology Fellowship Program administered by the Council of State and Territorial Epidemiologists (CSTE) and funded by the Centers for Disease Control and Prevention (CDC) Cooperative Agreement Number 1NU38OT000297-03-00.

Funding information

Centers for Disease Control and Prevention (CDC), Grant/Award Number: 1NU38OT000297-03-00; National Institutes of Health, Grant/Award Number: R01CA24986701

DATA AVAILABILITY STATEMENT

Research data are not shared.

REFERENCES

Aggarwal D, Warmerdam B, Wyatt K, Ahmad S, & Shaw GM (2015). Prevalence of birth defects among American-Indian births in California, 1983-2010. Birth Defects Research Part A: Clinical and Molecular Teratology, 103(2), 105–110. 10.1002/bdra.23341 [PubMed: 25721951]

Apperley L, Das U, Ramakrishnan R, Dharmaraj P, Blair J, Didi M, & Senniappan S (2018). Mode of clinical presentation and delayed diagnosis of turner syndrome: A single centre UK study. International Journal of Pediatric Endocrinology, 2018(1), 4. 10.1186/s13633-018-0058-1 [PubMed: 29983717]

Canfield MA, Mai CT, Wang Y, O'Halloran A, Marengo LK, Olney RS, … Network, f. t. N. B. D. P. (2014). The association between race/ethnicity and major birth defects in the United States, 1999–2007. American Journal of Public Health, 104(9), e14–e23.10.2105/ajph.2014.302098

Cramer JW, Bartz PJ, Simpson PM, & Zangwill SD (2014). The spectrum of congenital heart disease and outcomes after surgical repair among children with turner syndrome: A single-center review. Pediatric Cardiology, 35(2), 253–260. 10.1007/s00246-013-0766-5 [PubMed: 23933717]

Daly L (1992). Simple SAS macros for the calculation of exact binomial and Poisson confidence limits. Computers in Biology and Medicine, 22(5), 351–361. 10.1016/0010-4825(92)90023-G [PubMed: 1424580]

Hartman RJ, Rasmussen SA, Botto LD, Riehle-Colarusso T, Martin CL, Cragan JD, … Correa A (2011). The contribution of chromosomal abnormalities to congenital heart defects: A population-based study. Pediatric Cardiology, 32(8), 1147–1157. 10.1007/s00246-011-0034-5 [PubMed: 21728077]

Kosiv KA, Gossett JM, Bai S, & Collins RT (2017). Congenital heart surgery on in-hospital mortality in trisomy 13 and 18. Pediatrics, 140(5), e20170772. 10.1542/peds.2017-0772 [PubMed: 29046387]

Mahle WT, Newburger JW, Matherne GP, Smith FC, Hoke TR, Koppel R, … Committee on Fetus and Newborn. (2009). Role of pulse oximetry in examining newborns for congenital heart disease: A

scientific statement from the AHA and AAP. Pediatrics, 124(2), 823–836. 10.1542/peds.2009-1397 [PubMed: 19581259]

Mai CT, Isenburg JL, Canfield MA, Meyer RE, Correa A, Alverson CJ, … Network, N. B. D. P. (2019). National population-based estimates for major birth defects, 2010–2014. Birth Defects Research, 111(18), 1420–1435. 10.1002/bdr2.1589 [PubMed: 31580536]

Mai CT, Riehle-Colarusso T, O'Halloran A, Cragan JD, Olney RS, Lin A, … Network, f. t. N. B. D. P. (2012). Selected birth defects data from population-based birth defects surveillance programs in the United States, 2005–2009: Featuring critical congenital heart defects targeted for pulse oximetry screening. Birth Defects Research Part A: Clinical and Molecular Teratology, 94(12), 970–983. 10.1002/bdra.23098 [PubMed: 24083317]

Marengo LK, Flood TJ, Ethen MK, Kirby RS, Fisher S, Copeland G, … Network, f. t. N. B. D. P. (2018). Study of selected birth defects among American Indian/Alaska Native population: A multi-state population-based retrospective study, 1999–2007. Birth Defects Research, 110(19), 1412–1418. 10.1002/bdr2.1397 [PubMed: 30403007]

Marino B, Digilio MC, Toscano A, Anaclerio S, Giannotti A, Feltri C, … Dallapiccola B (2001). Anatomic patterns of conotruncal defects associated with deletion 22q11. Genetics in Medicine, 3(1), 45–48. 10.1097/00125817-200101000-00010 [PubMed: 11339377]

Martin GR, Ewer AK, Gaviglio A, Hom LA, Saarinen A, Sontag M, … Oster ME (2020). Updated strategies for pulse oximetry screening for critical congenital heart disease. Pediatrics, 146(1), e20191650. 10.1542/peds.2019-1650 [PubMed: 32499387]

Mitchell FM, Sangalang C, Lechuga-Peña S, Lopez K, & Beccera D (2020). Health inequities in historical context: A critical race theory analysis of diabetes among African Americans and American Indians. Race and Social Problems, 12(4), 289–299. 10.1007/s12552-020-09301-4

Mostefa-Kara M, Houyel L, & Bonnet D (2018). Anatomy of the ventricular septal defect in congenital heart defects: A random association? Orphanet Journal of Rare Diseases, 13(1), 118. 10.1186/s13023-018-0861-z [PubMed: 30021599]

Oster ME, Aucott SW, Glidewell J, Hackell J, Kochilas L, Martin GR, … Kemper AR (2016). Lessons learned from newborn screening for critical congenital heart defects. Pediatrics, 137(5), e20154573. 10.1542/peds.2015-4573 [PubMed: 27244826]

Oster ME, Lee KA, Honein MA, Riehle-Colarusso T, Shin M, & Correa A (2013). Temporal trends in survival among infants with critical congenital heart defects. Pediatrics, 131(5), e1502–e1508. 10.1542/peds.2012-3435 [PubMed: 23610203]

Øyen N, Poulsen G, Boyd HA, Wohlfahrt J, Jensen PKA, & Melbye M (2009). Recurrence of congenital heart defects in families. Circulation, 120(4), 295–301. 10.1161/CIRCULATIONAHA.109.857987 [PubMed: 19597048]

Pace ND, Oster ME, Forestieri NE, Enright D, Knight J, & Meyer RE (2018). Sociodemographic factors and survival of infants with congenital heart defects. Pediatrics, 142(3), e20180302. 10.1542/peds.2018-0302 [PubMed: 30111552]

Reller MD, Strickland MJ, Riehle-Colarusso T, Mahle WT, & Correa A (2008). Prevalence of congenital heart defects in metropolitan Atlanta, 1998-2005. The Journal of Pediatrics, 153(6), 807–813. 10.1016/j.jpeds.2008.05.059 [PubMed: 18657826]

Remien K, & Majmundar SH (2021). Physiology, fetal circulation. Treasure Island, FL: StatPearls Publishing.

Ryan AK, Goodship JA, Wilson DI, Philip N, Levy A, Seidel H, … Scambler PJ (1997). Spectrum of clinical features associated with interstitial chromosome 22q11 deletions: A European collaborative study. Journal of Medical Genetics, 34(10), 798–804. 10.1136/jmg.34.10.798 [PubMed: 9350810]

Sumal AS, Kyriacou H, & Mostafa AMHAM (2020). Tricuspid atresia: Where are we now? Journal of Cardiac Surgery, 35(7), 1609–1617. 10.1111/jocs.14673 [PubMed: 32484582]

Tinker SC, Gilboa SM, Moore CA, Waller DK, Simeone RM, Kim SY, … Reefhuis J (2020). Specific birth defects in pregnancies of women with diabetes: National Birth Defects Prevention Study, 1997–2011. American Journal of Obstetrics and Gynecology, 222(2), 176.e1–176.e11. 10.1016/j.ajog.2019.08.028 [PubMed: 31454511]

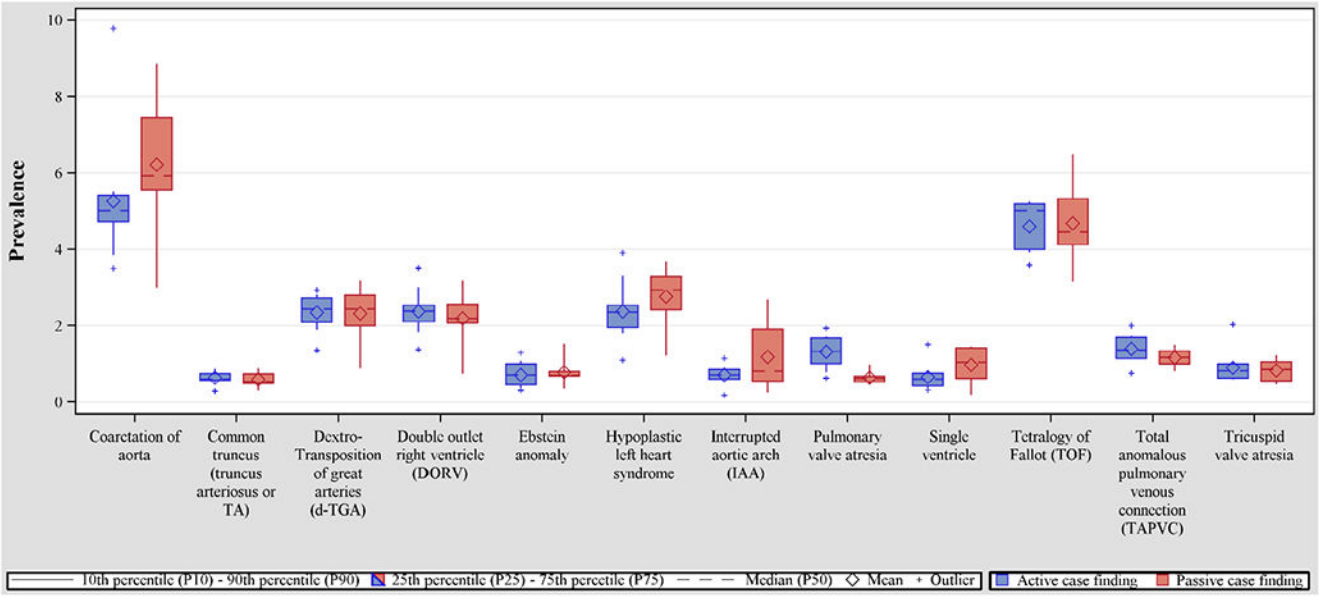

FIGURE 1.

Distribution of critical congenital heart defect (CCHD) prevalence (per 10,000 live births) by case-finding methodology for 19 U.S. population-based surveillance programs (programs with active case-finding methodology: Arizona, California, Delaware, Georgia (Metropolitan Atlanta), North Carolina, Louisiana, Minnesota, Puerto Rico, South Carolina, Texas, and Utah.

Programs with passive case-finding methodology: Colorado, Florida, Illinois, Kentucky, New Jersey, New York, Tennessee, and Virginia. Birth defect surveillance programs may have modified the requested code ranges used to define a select defect as necessary. Programs provided the code ranges used to define each birth defect where they differed from those requested by the NBDPN (appendix 3.1). If a program defined a birth defect using a different code range then the created estimates use the program-specific code range, when no alternate code range was specified the NBDPN code range was used), 2014–2018

TABLE 1

CCHD, cardiovascular, and chromosomal birth defect diagnosis codes

	ICD-9-CM	ICD-10-CM	CDC/BPA
CCHDs			
Coarctation of the aorta	747.10	Q25.1	747.10–747.19
Common truncus	745.0	Q20.0	745 (excluding 745.01)
Double outlet right ventricle	745.11	Q20.1	745.13–745.15
Ebstein anomaly	746.2	Q22.5	746.20
Hypoplastic left heart syndrome	746.7	Q23.4	746.70
Interrupted aortic arch)	747.11	Prior to January 10, 2016: Q25.2, Q25.4; post January 10, 2016: Q25.21	747.215–747.217, 747.285
Pulmonary valve atresia	746.01	Q22.0	746.00
Single ventricle	745.3	Q20.4	745.3
Tetralogy of Fallot	745.2	Q21.3	745.20–745.21, 747.31
Total anomalous pulmonary venous connection	747.41	Q26.2	747.42
Dextro-transposition of the great arteries	745.10	Q20.3	745.10, 745.11, 745.18, 745.19
Tricuspid valve atresia	746.1	Q22.4	746.100
Other cardiovascular birth defects			
Aortic valve stenosis	746.3	Q23.0	746.3
Atrial septal defect	745.5	Q21.1	745.51–745.59
Atrioventricular septal defect	745.60, 745.61, 745.69	Q21.2	745.60–745.69, 745.487
Ventricular septal defect	745.4	Q21.0	745.40–745.49 (excluding 745.487, 745.498)
Chromosomal birth defects			
Deletion 22q11.2	758.32	Q93.81	758.37
Trisomy 13	758.1	Q91.4–Q91.7	758.10–758.19
Trisomy 18	758.2	Q91.0–Q91.3	758.20–758.29
Trisomy 21	758	Q90.0–Q90.9	758.00–758.09
Turner syndrome	758.6	Q96.0–Q96.9	758.60–758.69

Abbreviations: CDC/BPA = Centers for Disease Control and Prevention/British Pediatric Association; CCHD = critical congenital heart defect; ICD-9-CM = International Classification of Diseases, 9th revision, Clinical Modification; ICD-10-CM = International Classification of Diseases, 10th revision, Clinical Modification.

TABLE 2

l heart defect (CCHD) counts and prevalence (per 10,000 live births) for 19 U.S. population-based surveillance programs,[a] 2014-2018

tical Congenital Heart ects (CCHDs)[b]			Coarctation of aorta			Common truncus (truncus arteriosus or TA)			Dextro-Transposition of great arteries (d-TGA)			Double outlet right ventricle (DORV)			Ebstein anomaly			Hypoplastic left heart syndrome		
nt	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]
87	19.6	19.3-19.9	5,464	5.8	5.6-5.9	557	0.6	0.5-0.6	2,201	2.3	2.2-2.4	2,183	2.3	2.2-2.4	713	0.8	0.7-0.8	2,546	2.7	2.6-2.8
5	20.1	19.7-20.6	2,375	5.4	5.2-5.6	277	0.6	0.6-0.7	1,078	2.5	2.3-2.6	1,038	2.4	2.2-2.5	319	0.7	0.6-0.8	1,077	2.5	2.3-2.6
2	19.2	18.8-19.6	3,089	6.1	5.9-6.3	280	0.6	0.5-0.6	1,123	2.2	2.1-2.3	1,145	2.3	2.1-2.4	394	0.8	0.7-0.9	1,469	2.9	2.7-3.0
4	19.8	19.4-20.2	2,912	6.4	6.2-6.6	251	0.6	0.5-0.6	1,200	2.6	2.5-2.8	952	2.1	2.0-2.2	329	0.7	0.6-0.8	1,276	2.8	2.6-3.0
6	19.9	19.2-20.7	750	5.0	4.6-5.3	87	0.6	0.5-0.7	312	2.1	1.8-2.3	420	2.8	2.5-3.1	68	0.4	0.3-0.6	472	3.1	2.8-3.4
5	19.7	19.1-20.2	1,458	5.6	5.3-5.9	170	0.7	0.6-0.8	554	2.1	2.0-2.3	634	2.4	2.3-2.6	244	0.9	0.8-1.1	630	2.4	2.2-2.6
	16.3	15.2-17.4	214	3.9	3.4-4.5	28	0.5	0.3-0.7	86	1.6	1.3-1.9	114	2.1	1.7-2.5	47	0.9	0.6-1.1	80	1.5	1.2-1.8
	28.3	23.9-33.2	35	6.7	4.7-9.3	5	1.0	0.3-2.2	9	1.7	0.8-3.3	17	3.2	1.9-5.2	7	1.3	0.5-2.8	15	2.9	1.6-4.7

tical Congenital Heart ects (CCHDs)[b]			Coarctation of aorta			Common truncus (truncus arteriosus or TA)			Dextro-Transposition of great arteries (d-TGA)			Double outlet right ventricle (DORV)			Ebstein anomaly			Hypoplastic left heart syndrome		
nt	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]
744	18.8	18.5-19.1	4,335	5.5	5.4-5.7	442	0.6	0.5-0.6	1,815	2.3	2.2-2.4	1,726	2.2	2.1-2.3	565	0.7	0.7-0.8	2,079	2.7	2.5-2.8
61	23.1	22.3-23.9	1,118	6.9	6.5-7.3	113	0.7	0.6-0.8	377	2.3	2.1-2.6	444	2.7	2.5-3.0	146	0.9	0.8-1.1	447	2.8	2.5-3.0
694	21.9	21.2-22.3	3,145	6.5	6.3-6.7	297	0.6	0.5-0.7	1,431	3.0	2.8-3.1	1,245	2.6	2.4-2.7	371	0.8	0.7-0.8	1,456	3.0	2.9-3.2
59	17.2	16.8-17.6	2,317	5.0	4.8-5.2	259	0.6	0.5-0.6	766	1.7	1.5-1.8	938	2.0	1.9-2.2	342	0.7	0.7-0.8	1,086	2.3	2.2-2.5

errupted aortic arch A)[c]			Pulmonary valve atresia			Single ventricle			Tetralogy of Fallot (TOF)			Total anomalous pulmonary venous connection(TAPVC)			Tricuspid valve atresia[d]		
unt	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]
1	0.9	0.8-0.9	942	1.0	0.9-1.1	852	0.9	0.8-1.0	4,592	4.8	4.7-5.0	1,234	1.3	1.2-1.4	813	0.9	0.8-0.9
1	0.8	0.7-0.9	616	1.4	1.3-1.5	318	0.7	0.6-0.8	2,125	4.8	4.6-5.1	653	1.5	1.4-1.6	432	1.0	0.9-1.1
0	0.9	0.9-1.0	326	0.6	0.6-0.7	534	1.1	1.0-1.1	2,467	4.9	4.7-5.1	581	1.1	1.1-1.2	381	0.7	0.7-0.8
3	0.8	0.8-0.9	359	0.8	0.7-0.9	359	0.8	0.7-0.9	2,141	4.7	4.5-4.9	442	1.0	0.9-1.1	357	0.8	0.7-0.9

Birth Defects Res. Author manuscript; available in PMC 2022 March 17.

Variable values	Interrupted aortic arch (IAA)[c]			Pulmonary valve atresia			Single ventricle			Tetralogy of Fallot (TOF)			Total anomalous pulmonary venous connection(TAPVC)			Tricuspid valve atresia[d]		
	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]	Count	Prevalence	95% CI[e]
Black, Non-Hispanic	162	1.1	0.9-1.3	184	1.2	1.0-1.4	170	1.1	1.0-1.3	861	5.7	5.3-6.1	178	1.2	1.0-1.4	170	1.1	1.0-1.3
Hispanic	214	0.8	0.7-0.9	304	1.2	1.0-1.3	258	1.0	0.9-1.1	1,180	4.5	4.3-4.8	493	1.9	1.7-2.1	227	0.9	0.8-1.0
Asian or Pacific Islander, Non-Hispanic	22	0.4	0.3-0.6	60	1.1	0.8-1.4	38	0.7	0.5-1.0	259	4.7	4.2-5.3	90	1.6	1.3-2.0	34	0.6	0.4-0.9
American Indian or Alaska Native, Non-Hispanic	5	1.0	0.3-2.3	20	3.8	2.3-5.9	3	0.6	0.1-1.7	41	7.8	5.6-10.6	14	2.7	1.5-4.5	11	2.1	1.0-3.8
Maternal age (years)[f]																		
<35	659	0.8	0.8-0.9	771	1.0	0.9-1.1	689	0.9	0.8-0.9	3,514	4.5	4.3-4.6	1,041	1.3	1.2-1.4	651	0.8	0.8-0.9
35+	145	0.9	0.8-1.1	166	1.0	0.9-1.2	157	1.0	0.8-1.1	1,050	6.5	6.1-6.9	187	1.2	1.0-1.3	157	1.0	0.8-1.1
Infant sex[f]																		
Male	437	0.9	0.8-1.0	501	1.0	0.9-1.1	487	1.0	0.9-1.1	2,532	5.2	5.0-5.4	708	1.5	1.4-1.6	430	0.9	0.8-1.0
Female	374	0.8	0.7-0.9	438	0.9	0.9-1.0	364	0.8	0.7-0.9	2,051	4.4	4.2-4.6	525	1.1	1.0-1.2	381	0.8	0.7-0.9

[a] Programs with active case-finding methodology: Arizona, California, Delaware, Georgia (Metropolitan Atlanta), Louisiana, North Carolina, Minnesota, Puerto Rico, South Carolina, Texas, Utah (total live births=4,388,631). Programs with passive case-finding methodology: Colorado, Florida, Illinois, Kentucky, New Jersey, New York, Tennessee, Virginia (total live births=5,080,694). Birth defect surveillance programs may have modified the requested code ranges used to define a select defect as necessary. Programs provided the code ranges used to define each birth defect where they differed from those requested by the National Birth Defects Prevention Network (NBDPN) [Table 1]. If a program defined a birth defect using a different code range then the created estimates use the program-specific code range, when no alternate code range was specified the NBDPN code range was used.

[b] The CCHDs column displays a count, prevalence, and CI for cases with any of the individual CCHDs presented in the table. Cases with more than one CCHD code were counted only once in this summarized category.

[c] Excludes Minnesota in birth year 2014.

[d] Select states could not exclude cases with stenosis.

[e] CI: Confidence interval calculated using exact Poisson methodology.

[f] Counts across subgroups may not add to the total due to other/unknown categories (not shown).

TABLE 3

CCHDs counts and prevalence (per 10,000 live births) for nine active case-finding population-based surveillance programs that ascertained more than live births, 2014–2018

	CCHDs[a]		
Variable values	**Count**	**Prevalence**	**95% CI[b]**
Total	7,726	20.2	19.8–20.7
Maternal race/ethnicity[c]			
White, non-Hispanic	3,148	20.4	19.7–21.2
Black, non-Hispanic	1,072	19.6	18.5–20.9
Hispanic	2,962	20.4	19.7–21.2
Asian or Pacific Islander, non-Hispanic	330	17.9	16.0–19.9
American Indian or Alaska Native, non-Hispanic	107	28.3	23.2–34.2
Maternal age (years)[c]			
<35	6,219	19.1	18.6–19.6
35+	1,497	26.6	25.2–27.9
Infant sex[c]			
Male	4,412	22.6	21.9–23.3
Female	3,302	17.7	17.1–18.3

Abbreviations: CCHD = critical congenital heart defect; CI = confidence interval; NBDPN = National Birth Defects Prevention Network.

Note: Programs with active case-finding methodology that ascertained more than live births: Arizona, California, Delaware, Georgia (Metropolitan Atlanta), North Carolina, Puerto Rico, South Carolina, Texas, and Utah (total live births = 3,817,972). Programs provided the code ranges used to define each birth defect where they differed from those requested by the NBDPN (appendix 3.1). If a program defined a birth defect using a different code range then the created estimates use the program-specific code range, when no alternate code range was specified the NBDPN code range was used. Cases were included when gestational age was greater than or equal to 20 completed weeks gestation. If gestational age was missing birth weight was used as a proxy.

[a]The CCHDs column displays a count, prevalence, and CI for of cases with any of the individual CCHDs presented in the article. Cases with more than one CCHD code were counted only once in this summarized category.

[b]CI calculated using exact Poisson methodology.

[c]Counts across subgroups may not add to the total due to other/unknown categories (not shown).

TABLE 4

ardiovascular and chromosomal birth defects for critical congenital heart defect cases (CCHDs) from 9 active case-finding population-nce programs that ascertained more than live births,[a] 2014-2018

	Critical Congenital Heart Defects (CCHDs)[b] (n=7,726)			Coarctation of aorta (n=2,074)			Common truncus (truncus arteriosus or TA) (n=249)			Dextro-Transposition of great arteries(d-TGA) (n=942)			Double outlet right ventricle (DORV) (n=907)			Ebstein anomaly (n=283)			Hypoplastic left heartsyndrome (n=948)		
	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]
)																					
	247	3.2	2.8-3.6	172	8.3	7.1-9.6	4	1.6	0.4-4.1	17	1.8	1.1-2.9	25	2.8	1.8-4.0	3	1.1	0.2-3.1	10	1.1	0.5-1.9
d	2,440	38.9	37.7-40.1	583	35.9	33.5-38.2	86	42.0	35.1-49.0	368	47.0	43.5-50.6	310	43.1	39.4-46.8	84	37.5	31.1-44.2	308	41.2	37.7-44.9
	499	6.5	5.9-7.0	113	5.4	4.5-6.5	10	4.0	1.9-7.3	71	7.5	5.9-9.4	135	14.9	12.6-17.4	2	0.7	0.1-2.5	49	5.2	3.8-6.8
a	--[g]			--			4	1.6	0.4-4.1	99	10.5	8.6-12.6	119	13.1	11.0-15.5	9	3.2	1.5-6.0	220	23.2	20.6-26.0
	--[g]			4	0.2	0.1-0.5	--			5	0.5	0.2-1.2	1	0.1	0.0-0.6	0			2	0.2	0.0-0.8
	--[g]			99	4.8	3.9-5.8	5	2.0	0.7-4.6	--			47	5.2	3.8-6.8	5	1.8	0.6-4.1	14	1.5	0.8-2.5
	--[g]			119	5.7	4.8-6.8	1	0.4	0.0-2.2	47	5.0	3.7-6.6	--			4	1.4	0.4-3.6	79	8.3	6.7-10.3
	--[g]			9	0.4	0.2-0.8	0			5	0.5	0.2-1.2	4	0.4	0.1-1.1	--			1	0.1	0.0-0.6
	--[g]			220	10.6	9.3-12.0	2	0.8	0.1-2.9	14	1.5	0.8-2.5	79	8.7	7.0-10.7	1	0.4	0.0-2.0	--		
	--[g]			28	1.4	0.9-1.9	24	9.6	6.3-14.0	23	2.4	1.6-3.6	26	2.9	1.9-4.2	2	0.7	0.1-2.5	20	2.1	1.3-3.2

	Critical Congenital Heart Defects (CCHDs)[b] (n=7,726)			Coarctation of aorta (n=2,074)			Common truncus (truncus arteriosus or TA) (n=249)			Dextro-Transposition of great arteries(d-TGA) (n=942)			Double outlet right ventricle (DORV) (n=907)			Ebstein anomaly (n=283)			Hypoplastic left heartsyndrome (n=948)		
	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]
	--[g]			4	0	0.1-0.5	5	2.0	0.7-4.6	58	6.2	4.7-7.9	100	11.0	9.1-13.2	32	11.3	7.9-15.6	9	0.9	0.4-1.8
	--[g]			40	1.9	1.4-2.6	2	0.8	0.1-2.9	81	8.6	6.9-10.6	64	7.1	5.5-8.9	3	1.1	0.2-3.1	18	1.9	1.1-3.0
	--[g]			8	0.4	0.2-0.8	6	2.4	0.9-5.2	27	2.9	1.9-4.1	112	12.3	10.3-14.7	8	2.8	1.2-5.5	1	0.1	0.0-0.6
C)	--[g]			30	1.4	1.0-2.1	3	1.2	0.2-3.5	35	3.7	2.6-5.1	80	8.8	7.1-10.9	0			29	3.1	2.1-4.4
	--[g]			35	1.7	1.2-2.3	3	1.2	0.2-3.5	62	6.6	5.1-8.4	26	2.9	1.9-4.2	3	1.1	0.2-3.1	8	0.8	0.4-1.7
	1,494	21.7	20.7-22.6	634	34.0	31.8-36.2	101	44.5	37.9-51.2	196	23.0	20.2-26.0	294	37.5	34.1-41.0	37	14.7	10.6-19.7	129	15.3	12.9-17.9
	1,218	**15.8**	**15.0-16.6**	**318**	**15.3**	**13.8-17.0**	**65**	**26.1**	**20.8-32.0**	**55**	**5.8**	**4.4-7.5**	**152**	**16.8**	**14.4-19.4**	**21**	**7.4**	**4.7-11.1**	**127**	**13.4**	**11.3-15.7**
e	144	2.5	2.1-2.9	1	0.1	0.0-0.4	25	13.7	9.1-19.6	0			5	0.7	0.2-1.7	0			0		
	82	1.1	0.8-1.3	16	0.8	0.4-1.2	4	1.6	0.4-4.1	3	0.3	0.1-0.9	20	2.2	1.4-3.4	0			13	1.4	0.7-2.3
	132	1.7	1.4-2.0	25	1.2	0.8-1.8	0			2	0.2	0.0-0.8	51	5.6	4.2-7.3	0			21	2.2	1.4-3.4
n	282	3.7	3.2-4.1	81	3.9	3.1-4.8	3	1.2	0.2-3.5	3	0.3	0.1-0.9	15	1.7	0.9-2.7	11	3.9	2.0-6.8	4	0.4	0.1-1.1
	70	1.0	0.8-1.3	57	3.1	2.3-3.9	0			0			0			0			18	2.1	1.3-3.3

	Interrupted aortic arch (IAA) (n=298)			Pulmonary valve atresia (n=555)			Single ventricle (n=278)			Tetralogy of Fallot (TOF) (n=1,850)			Total anomalous pulmonary venous connection(TAPVC) (n=585)			Tricuspid valve atresia (n=392)		
	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]
)																		

Variable values	Interrupted aortic arch (IAA) (n=298)			Pulmonary valve atresia (n=555)			Single ventricle (n=278)			Tetralogy of Fallot (TOF) (n=1,850)			Total anomalous pulmonary venous connection(TAPVC) (n=585)			Tricuspid valve atresia (n=392)		
	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]	Count	Percent	95% CI[c]
Aortic valve stenosis	36	12.1	8.6-16.3	7	1.3	0.5-2.6	8	2.9	1.3-5.6	6	0.3	0.1-0.7	7	1.2	0.5-2.4	9	2.3	1.1-4.3
Atrial septal defect[d]	141	47.3	41.5-53.2	169	38.5	33.9-43.2	104	41.6	35.4-48.0	516	32.3	30.0-34.6	245	51.3	46.7-55.8	161	47.5	42.1-53.0
Atrioventricular septal defect	11	3.7	1.9-6.5	90	16.2	13.2-19.6	57	20.5	15.9-25.7	93	5.0	4.1-6.1	99	16.9	14.0-20.2	29	7.4	5.0-10.5
Coarctation of aorta	28	9.4	6.3-13.3	4	1	0.2-1.8	40	14.4	10.5-19.1	8	0.4	0.2-0.9	30	5.1	3.5-7.2	35	8.9	6.3-12.2
Common truncus (truncus arteriosus or TA)	24	8.1	5.2-11.7	5	0.9	0.3-2.1	2	0.7	0.1-2.6	6	0.3	0.1-0.7	3	0.5	0.1-1.5	3	0.8	0.2-2.2
Dextro-Transposition of great arteries (d-TGA)	23	7.7	5.0-11.4	58	10.5	8.0-13.3	81	29.1	23.9-34.9	27	1.5	1.0-2.1	35	6.0	4.2-8.2	62	15.8	12.3-19.8
Double outlet right ventricle (DORV)	26	8.7	5.8-12.5	100	18.0	14.9-21.5	64	23.0	18.2-28.4	112	6.1	5.0-7.2	80	13.7	11.0-16.7	26	6.6	4.4-9.6
Ebstein anomaly	2	0.7	0.1-2.4	32	5.8	4.0-8.0	3	1.1	0.2-3.1	8	0.4	0.2-0.9	0			3	0.8	0.2-2.2
Hypoplastic left heart syndrome	20	6.7	4.1-10.2	9	1.6	0.7-3.1	18	6.5	3.9-10.0	1	0.1	0.0-0.3	29	5.0	3.3-7.0	8	2.0	0.9-4.0
Interrupted aortic arch (IAA)	--			0			14	5.0	2.8-8.3	3	0.2	0.0-0.5	1	0	0.0-0.9	13	3.3	1.8-5.6
Pulmonary valve atresia	0			--			52	18.7	14.3-23.8	--[g]			60	10.3	7.9-13.0	81	20.7	16.8-25.0
Single ventricle	14	4.7	2.6-7.8	52	9.4	7.1-12.1	--			18	1.0	0.6-1.5	41	7.0	5.1-9.4	35	8.9	6.3-12.2
Tetralogy of Fallot (TOF)	3	1.0	0.2-2.9	--[g]			18	6.5	3.9-10.0	--			11	1.9	0.9-3.3	26	6.6	4.4-9.6
Total anomalous pulmonary venous connection(TAPVC)	1	0	0.0-1.9	60	10.8	8.4-13.7	41	14.7	10.8-19.5	11	0.6	0.3-1.1	--			13	3.3	1.8-5.6

	Interrupted aortic arch (IAA) (n=298)			Pulmonary valve atresia (n=555)			Single ventricle (n=278)			Tetralogy of Fallot (TOF) (n=1,850)			Total anomalous pulmonary venous connection(TAPVC) (n=585)			Tricuspid valve atresia (n=392)		
Variable values	**Count**	**Percent**	**95% CI[c]**	**Count**	**Percent**	**95% CI[c]**	**Count**	**Percent**	**95% CI[c]**	**Count**	**Percent**	**95% CI[c]**	**Count**	**Percent**	**95% CI[c]**	**Count**	**Percent**	**95% CI[c]**
Tricuspid valve atresia	13	4.4	2.3-7.3	81	14.6	11.8-17.8	35	12.6	8.9-17.1	26	1.4	0.9-2.1	13	2.2	1.2-3.8	--		
Ventricular septal defect[e]	172	64.7	58.6-70.4	--[g]			60	23.3	18.2-28.9	--[g]			49	9.6	7.2-12.5	139	39.3	34.1-44.6
Chromosomal (758, Q90-99)	**91**	**30.5**	**25.4-36.1**	**34**	**7.2**	**5.0-9.9**	**24**	**8.6**	**5.6-12.6**	**423**	**22.9**	**21.0-24.8**	**38**	**6.5**	**4.6-8.8**	**48**	**12.2**	**9.2-15.9**
Deletion 22q 11.2[e]	49	21.9	16.6-27.9	53	9.5	7.2-12.3	0			63	4.5	3.5-5.8	0			1	0.4	0.0-2.4
Trisomy 13	2	0.7	0.1-2.4	2	0.5	0.1-1.9	1	0.4	0.0-2.0	30	1.6	1.1-2.3	0			3	0.8	0.2-2.2
Trisomy 18	5	1.7	0.5-3.9	5	0.9	0.3-2.1	3	1.1	0.2-3.1	30	1.6	1.1-2.3	0			9	2.3	1.1-4.3
Trisomy 21 (Down syndrome)	4	1.3	0.4-3.4	1	0.2	0.0-1.0	6	2.2	0.8-4.6	159	8.6	7.4-10.0	2	0.3	0.0-1.2	5	1.3	0.4-3.0
Turner syndrome[f]	2	0.8	0.1-2.7	10	2	0.9-3.3	0			0			1	0.2	0.0-1.1	1	0	0.0-1.6

[a] Programs with active case-finding methodology that ascertained more than live births: Arizona, California, Delaware, Georgia (Metropolitan Atlanta), North Carolina, Puerto Rico, South Carolina, Texas, Utah. Programs provided the code ranges used to define each birth defect where they differed from those requested by the National Birth Defects Prevention Network (NBDPN) [appendix 3.1]. If a program defined a birth defect using a different code range then the created estimates use the program-specific code range, when no alternate code range was specified the NBDPN code range was used. Cases were included when gestational age was greater than or equal to 20 completed weeks gestation. If gestational age was missing birth weight was used as a proxy.

[b] The CCHDs column displays a count, prevalence, and CI for cases with any of the individual CCHDs presented in the table. Cases with more than one CCHD code were counted only once in this summarised category.

[c] CI: Confidence interval calculated using exact binomial methodology.

[d] Excludes Arizona and Utah.

[e] Excludes Arizona.

[f] Excludes Arizona. Percent co-occurring is calculated as female and unknown cases of Turner syndrome divided by female cases of each CCHD.

[g] Cells are left blank where the NBDPN case definition stipulates that the two birth defects cannot be reported together or where one condition is considered part of another.

Birth Defects Res. Author manuscript; available in PMC 2022 March 15.