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PREVALENCE AND PATTERN OF CHD AND EXTRA CARDIAC DEFECTS IN PEDIATRIC POPULATION WITH CHD PRESENTED TO TERTIARY CARE CENTRE:- A PROSPECTIVE STUDY FROM NORTHERN INDIA

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Abstract

Background: Congenital heart disease (CHD) represents the most common congenital malformation worldwide, contributing significantly to infant morbidity and mortality. The prevalence is notably high in developing countries like India, where high birth rates, limited resources, and genetic and environmental factors increase disease burden. **Aim**: To study the clinical and demographic profile, socio-epidemiological characteristics, types and distribution of congenital heart diseases, and associated extracardiac anomalies among pediatric patients diagnosed with CHD in a tertiary care setting. **Methods**: A prospective observational study was conducted over two years at G.B. Pant Hospital, Government Medical College, Srinagar. A total of 61,254 children were screened, of whom 640 were diagnosed with CHD, yielding a prevalence of 10.14 per 1000 live births. Children aged 1 day to 18 years meeting inclusion criteria were enrolled. Detailed data on demographics, socioeconomic status, family history, maternal and birth factors, and associated anomalies were collected and analyzed. **Results**: Most patients (73.8%) were under six years of age. The male to female ratio was 1.2:1. Acyanotic CHDs constituted 81.3% of cases, with ventricular septal defect (35%), atrial septal defect (30%), and patent ductus arteriosus (10%) being most common. Cyanotic CHDs comprised 18.7%, primarily d-TGA (6.5%) and TOF (5%). A significant proportion (87.4%) of children belonged to the lower socioeconomic class. Consanguinity was present in 20.6% of cases, and extracardiac anomalies were found in 20%, with syndromes such as Down syndrome being the most frequent (54.7% among syndromic cases). Birth order, maternal age, and gestational parameters also showed associations with CHD occurrence. **Conclusion**: This study underscores the importance of early screening, awareness of syndromic associations, and addressing socio-demographic risk factors in managing congenital heart disease. A multidisciplinary and preventive approach is essential for reducing long-term complications and improving outcomes in children with CHD.

Keywords: Congenital heart disease, acyanotic CHD, cyanotic CHD, extracardiac anomalies, Down syndrome, consanguinity, pediatric cardiology, socioeconomic factors.

Introduction

The term congenital originates from the Latin con (together) and genitus (born), implying a condition present at birth. However, congenital heart disease (CHD) is more nuanced than simply being "present at birth." Most structural heart anomalies are established by six weeks of gestation and remain compatible with fetal life, though they may not reveal their full clinical profile until weeks, months, or even years later [1].

CHD is defined as a functional or structural abnormality in the cardiovascular system present at birth, even if diagnosed much later [2–4]. It is not a static defect but evolves with growth and postnatal circulatory adjustments. The incidence of moderate to severe congenital heart defects remains steady at 6–8 per 1000 live births globally [5–8]. In India, this burden is significant and growing [3,7].

Early diagnosis is crucial, as 2–3 per 1000 newborns show symptoms in the first year of life, and up to 50–60% are diagnosed within the first month [9]. Advances in neonatal care and surgical interventions have improved survival rates, making long-term follow-up more important than ever [9,10]. The timing and symptomatology of CHD depend on anatomical severity, prenatal effects, and postnatal circulatory shifts such as ductal closure and decreased pulmonary vascular resistance [6,9]. For instance, left-to-right shunting defects like ventricular septal defects (VSDs) often manifest heart failure symptoms at 1–3 months of age as pulmonary resistance falls [9].

CHD can be broadly categorized as mild, moderate, or severe. Severe CHD includes cyanotic lesions and critical acyanotic defects needing early interventions, such as large VSDs, PDAs, and AVSDs. Moderate CHD requires expert care but is less urgent, while mild forms often resolve spontaneously [10].

While cardiac signs—cyanosis, shock, or murmurs—guide initial diagnosis, extracardiac anomalies (ECAs) play a crucial diagnostic and prognostic role. Systemic evaluations are necessary, as 20–45% of children with CHD have associated extracardiac anomalies [18,19], and 5–10% show chromosomal abnormalities [20]. Major anomalies affect medical or surgical outcomes, while minor anomalies may act as markers for hidden major anomalies. Importantly, 90% of infants with three or more minor anomalies harbor a major congenital defect [21].

ECAs are further categorized as:

* **Multiple congenital defects:** having at least one major or three minor defects without a defined syndrome [21].
* **Syndromes:** associated with chromosomal abnormalities or monogenic conditions like Down, Turner, Noonan, Holt-Oram, and DiGeorge syndromes [19,22,23].
* **Laterality defects:** malposition syndromes affecting embryonic left-right patterning, including situsinversus and heterotaxy syndromes [18,22–26].

A detailed understanding of ECAs in CHD cases aids in early diagnosis, risk stratification, multidisciplinary planning, and genetic counseling [27–30].

Materials and Methods

This was a hospital-based, prospective observational study conducted in the Postgraduate Department of Pediatrics at Government Medical College (GMC), Srinagar, a tertiary care referral center in North India. The study was carried out over a period of two years, from October 2020 to October 2022.

Study Population
The study included infants and children in the age group of 1 day to 12 years who presented to the Pediatric Department of GMC Srinagar and were diagnosed with congenital heart defects. The caregivers, primarily mothers, were included as key respondents to provide developmental and perinatal history.

Inclusion Criteria
1.Children aged from 1 day to 12 years with a confirmed diagnosis of congenital heart defects, with or without associated extracardiac anomalies.

Exclusion Criteria
1. Preterm neonates with patent ductus arteriosus.
2. Children with isolated bicuspid aortic valve.
3. Cases with only patent foramen ovale, considered a normal variant in neonates.

Ethical Considerations
The study protocol was approved by the Institutional Ethics Committee of GMC Srinagar. Informed consent was obtained from the parents or legal guardians of all enrolled participants before inclusion in the study.

Diagnostic Workup
All children underwent a thorough clinical evaluation, including detailed history taking and physical examination. The diagnosis of congenital heart defects was made based on the clinical suspicion and confirmed using the following investigations:
* Chest X-ray
* Electrocardiography (ECG)
* 2D echocardiography, performed by a pediatric cardiologist, which served as the definitive diagnostic tool for structural cardiac anomalies

Evaluation of Extracardiac Anomalies
Extracardiac defects were identified either clinically or through routine screening and specialized investigations. A combination of biochemical, radiological, and genetic tests was used to detect these anomalies. Anomalies were classified as major or minor based on their clinical significance.

Biochemical Investigations
* Complete blood count (CBC)
* Liver function tests (LFTs)
* Kidney function tests (KFTs)
* C-reactive protein (CRP)

Radiological Investigations
* Ultrasonography of the abdomen and/or skull to detect structural abnormalities
* Computed tomography (CT) scans for detailed anatomical imaging when indicated
* Magnetic resonance imaging (MRI), particularly in cases with suspected central nervous system involvement or soft tissue anomalies

Genetic and Systemic Evaluation
* G-banded karyotyping was conducted in selected cases to detect chromosomal abnormalities
* Fluorescence in situ hybridization (FISH) studies were performed for identifying microdeletions such as 22q11 deletion (DiGeorge syndrome)
* Audiometric evaluation to assess sensorineural or conductive hearing loss
* Ophthalmologic examination to detect structural or functional eye anomalies
* Thyroid hormone profiling to screen for congenital hypothyroidism or other endocrine disorders

The combination of these diagnostic modalities ensured a comprehensive evaluation of extracardiac birth defects in the study population.

Results

A total of 61,254 patients were screened over the two-year study period. Among these, 640 children were diagnosed with congenital heart disease (CHD), giving a prevalence of 10.14 per 1,000 live births. All 640 children who met the inclusion criteria were enrolled in the study.

The majority of enrolled children were younger than six years, accounting for 73.8% of the study population. Male children were slightly more prevalent (55%) than females, with a male-to-female ratio of 1.2:1. Most children belonged to the upper-lower (66.2%) or lower socio-economic class (21.2%). Consanguinity was reported in 20.6% of cases. The second birth order was most common, and the majority were term (93.8%) with normal birth weight (82.5%). Maternal age at the time of conception was predominantly between 19 and 35 years (92.5%).

Table 1: Demographic and Perinatal Characteristics of the Study Population

Variable	Category	Number (n=640)	Percentage (%)
Age	< 6 years	472	73.8
	≥ 6 years	168	26.2
Sex	Male	352	55.0
	Female	288	45.0
Socioeconomic Class	Upper middle	24	3.8
	Lower middle	56	8.8
	Upper lower	424	66.2
	Lower	136	21.2
Consanguinity	Present	132	20.6
	Absent	508	79.4
Birth Order	First	200	31.2
	Second	360	56.2
	Third	80	12.5
Gestational Age	Preterm (<37 weeks)	40	6.2
	Term (≥37 weeks)	600	93.8
Birth Weight	Normal	528	82.5
	Low birth weight (<2.5 kg)	112	17.5
Maternal Age at Conception	<19 years	40	6.2
	19–35 years	592	92.5
	>35 years	8	1.3

Of the total 640 children, acyanotic congenital heart defects were significantly more prevalent than cyanotic types. Acyanotic lesions accounted for 81.3%, with ventricular septal defect (VSD) being the most common (35%), followed by atrial septal defect (30%) and patent ductus arteriosus (10%). Among cyanotic lesions (18.7%), the most common were d-transposition of the great arteries (d-TGA, 6.5%) and Tetralogy of Fallot (TOF, 5%).

Table 2: Distribution According to Type of Congenital Heart Disease

Type of CHD	Specific Lesion	Number	Percentage (%)
Acyanotic (ACHD)	VSD	226	35.0
	ASD	192	30.0
	PDA	64	10.0
	Others	40	6.3
	Total ACHD	520	81.3
Cyanotic (CCHD)	d-TGA	42	6.5
	TOF	32	5.0
	TAPVC	14	2.3
	Others	48	5.0
	Total CCHD	120	18.7

Others (ACHD): Pulmonary stenosis, Aortic stenosis, Coarctation of Aorta, ALCAPA, CCTGA. Others (CCHD): Complex heart disease, Double outlet right ventricle, Ebstein anomaly, Truncus arteriosus, Taussig-Bing anomaly, DILV with PAH/PS Among all CHD patients, 20% (n=128) had associated extracardiac anomalies. Acyanotic CHD was associated with 12% of these cases and cyanotic CHD with 8%.

Table 3: Presence of Extracardiac Defects Among CHD Patients

CHD Type	With Extracardiac Defects	Without Extracardiac Defects	Total
Acyanotic (ACHD)	77 (12.0%)	443 (69.2%)	520
Cyanotic (CCHD)	51 (8.0%)	69 (10.8%)	120

Out of 128 patients with extracardiac anomalies, half were found to have syndromic associations. Multiple congenital defects were seen in 39.8% and laterality defects in 10.2%.

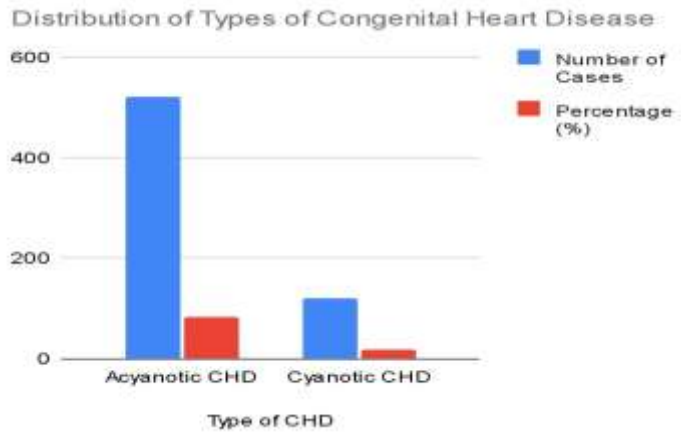
Table 4: System-wise Categorization of Extracardiac Anomalies

System-wise Category	Number	Percentage (%)
Syndromes	64	50.0
Multiple congenital defects	51	39.8
Laterality defects	13	10.2

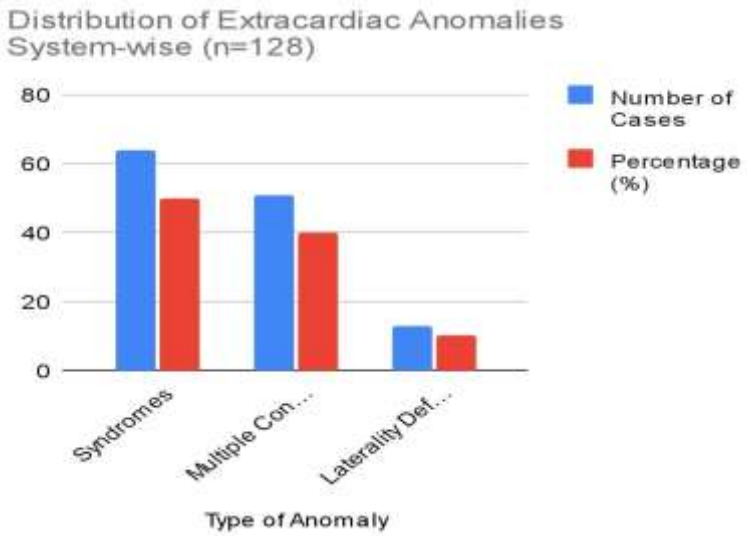
Down syndrome was the most commonly identified syndrome, observed in 54.7% of all syndromic cases. Other syndromes were less frequent but included Edwards, DiGeorge, Noonan, and Williams syndromes.

Table 5: Distribution of Syndromes Associated with Congenital Heart Disease

Syndrome	Number	Percentage (%)
Down syndrome	35	54.7
Edwards syndrome	3	4.7
DiGeorge syndrome	3	4.7
Holt-Oram syndrome	2	3.1
Williams syndrome	3	4.7
Turner syndrome	1	1.6
Noonan syndrome	2	3.1
Achondroplasia	3	4.7
Congenital rubella syndrome	3	4.7
Pierre Robin syndrome	3	4.7
Treacher Collins syndrome	2	3.1
Cri-du-chat	1	1.6
Marfan syndrome	2	3.1
Patau syndrome	1	1.6



Bar graph 1: Distribution of Types of congenital Heart disease



Bar graph 2: Distribution of Extracardiac Anomalies system -wise

Discussion

Congenital heart defect (CHD) is the most common congenital malformation among all birth defects, significantly contributing to morbidity and mortality in children. The burden is especially high in developing countries like India due to a high birth rate and the critical nature of CHDs that require advanced interventions. CHD may be diagnosed at any age, but some are more likely detected in neonates, while others may not be identified until later in life. Globally, CHDs constitute a major health issue, with a widely accepted prevalence of approximately 8 per 1000 live births [23]. Indian studies have reported a variation in prevalence from 2.25 to 26 per 1000 live births [24, 25, 26]. A recent systematic review also reported higher prevalence in Asia due to higher birth rates and consanguinity, particularly in Iran and India. In our study, the prevalence was 10.14 per 1000 live births, likely reflecting our position as a major referral center in Kashmir, use of better diagnostics, improved survival of premature infants, and high regional birth rates.

In our prospective observational study of 640 children aged 1 day to 18 years with congenital heart disease, 73.8% were below six years and 26.2% above. In this study, 55% were males and 45% females, producing a male-to-female ratio of 1.2:1. Rubia et al. [27], Singh G et al. [28], and Vaidyanathan B et al. [29] observed ratios ranging from 0.8:1 to 1.1:1. This similarity suggests an equal gender predilection, reflecting changing societal attitudes and improved healthcare access for both genders.

Among the 640 children enrolled, 81.3% had acyanotic CHD and 18.7% cyanotic CHD. The most prevalent lesion was VSD (35%), followed by ASD (30%), and PDA (10%). These findings align

with Smitha R et al. [30], Kapoor R et al. [31], Mishra et al. [32], Jatay et al. [33], and Abqari S et al. [34], who also noted VSD as the predominant lesion.

Socio-economic status revealed that 87.4% of children with CHD belonged to lower classes, with the majority from upper-lower and lower classes. This supports findings by Agha MM et al. [35] and Tandon S et al. [28] who also reported a high burden of CHD among low socio-economic groups.

Family history was rare—only 1.2% of patients had a relative with CHD. According to Nelson Textbook of Pediatrics [36], the risk of recurrence in first-degree relatives is around 2–6%, rising to 20–30% when two first-degree relatives are affected. Oyen N et al. [37], Ellesoe GS et al. [38], and others [39, 40] corroborated the strong familial clustering of CHD.

Maternal age distribution showed 6.2% below 19 years, 92.5% between 19–35 years, and 1.2% above 35 years. Best K.E. et al. [41] and Miller et al. [22] observed slightly increased risks of certain CHDs among mothers over 35 years. However, Luo YL et al. [42] noted a higher incidence of CHD in younger mothers.

Consanguinity was observed in 20.6% of cases. Gnanalingam MG et al. [43] noted consanguinity in 31.1% of CHD patients. Chehab G et al. [44] in Lebanon found significant associations with consanguinity, especially first-degree cousin marriages.

Birth order analysis revealed that 56.2% of CHD cases were second-born children. Rahman M et al. [45] and Howell EM [46] reported higher malnutrition and mortality with increasing birth order.

Gestational age findings showed 93.8% were term and 6.2% preterm. Birth weight analysis showed 17.5% were low birth weight. Steurer AM et al. [47] reported increased morbidity with CHD in preterm infants.

None of the mothers had fever, gestational diabetes, or pregnancy-induced hypertension, factors linked with CHD in studies by Ramakrishnan A et al. \[48], Boyd et al. [49], Tabib et al. [50], and others [51, 52].

Extracardiac anomalies were seen in 128 cases (20%). Similar frequencies were found in studies by Pradat [53] (25.7%), Bosi et al. [54] (24%), Julian and Farrú [55] (31.9%), and Abdullah et al. [56] (28.5%). Egbe et al. [57] reported a lower rate (13.6%), while Tennstedt et al. [58] reported a prevalence as high as 66% in necropsy studies.

Syndromes were the most common extracardiac anomaly (50%), followed by multiple congenital defects (39.8%), and laterality defects (10.2%). Bensemlali et al. [40] and Egbe et al. [57] emphasized the importance of standardized classification of anomalies.

Down syndrome was the most common associated syndrome (54.7%). This aligns with previous studies reporting 44–62% of CHD cases in patients with Down syndrome [59].

Musculoskeletal anomalies included club foot, cleft lip/palate, and polydactyly. Greenwood et al. [60] and Wallgren et al. [61] reported similar associations.

Genitourinary anomalies were observed in previous studies by Greenwood et al. [60], Gallo et al. [62], and Wallgren et al. [61], ranging from 5% to 13.1%. Associations were notably higher in patients with coarctation of the aorta and VSD.

Gastrointestinal anomalies like duodenal atresia, often linked with trisomy 21, were associated with CHD in studies by Touloukian [63], Fonkalsrud et al. [64], and Teixeira et al. [65].

CNS anomalies were observed in 6–7% of CHD cases, consistent with studies by Greenwood et al. [60], Wallgren et al. [61], and Gallo et al. [62]. No specific pattern was consistently noted.

Conclusion

This study provides a comprehensive profile of congenital heart disease (CHD) in children from a tertiary care hospital in Kashmir, highlighting both epidemiological patterns and associated risk factors. The majority of the affected children were under six years of age, with a slight male predominance, and most belonged to lower socioeconomic strata, underscoring the social determinants that may influence early detection and management of CHD.

In conclusion, CHD continues to be a major public health concern with significant clinical implications. Early diagnosis, equitable access to specialized care, and targeted preventive strategies can substantially reduce morbidity and mortality associated with these defects in pediatric populations.

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References:

1. Tse S. *Indian J Pediatr*. 2005; 72:595–598.
2. Hoffman J.I.E. *PediatrClin North Am*. 1990; 37:25–43.
3. Chadha S.L., Singh N., Shukla D.K. *Indian J Pediatr*. 2001; 68:507–510.
4. Hoffman J.I.E., Kaplan S. *J Am CollCardiol*. 2002; 39:1890–1900.
5. Wechsler S.B., Wernovsky G. *In: Cloherty J.P., Eichenwald E.C., Stark A.R. (eds.) Manual of Neonatal Care.* Philadelphia: Lippincott Williams & Wilkins; 2004. P.407.
6. Working Group on Management of Congenital Heart Disease in India. *Indian Pediatr*. 2008; 45:117.
7. Bernstein D. *In: Kliegman R.M., Behrman R.E., Jenson H.B., Stanton B.F. (eds.) Nelson Textbook of Pediatrics.* Philadelphia: Saunders; 2007. P.1878–1881.
8. Vaidyanathan B., Kumar R.K. *Congenital Cardiology Today*. 2005; 3(4):1–3.
9. Zeltser I., Tabbutt S. *In: Bell L.M., Vetter V.L. (eds.) Pediatric Cardiology – The Requisites in Pediatrics.* Philadelphia: Elsevier; 2006. P.31–33.
10. Sharma S. *In: Kulkarni M.L. (ed.) Pediatric Cardiology.* New Delhi: Jaypee Brothers; 2003. P.86–90.
11. Karande S., Patil V., Kher A., Muranjan M. *Indian Pediatr*. 2014; 51(5):389–918.
12. Egbe A., Lee S., Ho D., et al. *Ann PediatrCardiol*. 2014; 7(2):86–91.
13. Rasmussen S.A., Olney R.S., Holmes L.B., et al. *Birth Defects Res A ClinMolTeratol*. 2003; 67:193–201.
14. Jones K.L. *Smith's Recognizable Patterns of Human Malformations.* 6th ed. Philadelphia: Elsevier Saunders; 2006.
15. Miller A., Riehle C.T., Siffel C., et al. *Am J Med Genet A*. 2011; 9999:1–9.
16. Grech V., Gatt M. *Int J Cardiol*. 1999; 68:151–156.
17. Aase J.M. *PediatrClin North Am*. 1992; 39:135–156.
18. Swain S., Agarwal A., Bhatia B.D. *Indian Pediatr*. 1994; 31:1187–1191.
19. Oakley G.P. *ClinPerinatol*. 1986; 13:545–554.
20. Ravikumara M., Bhat B.V., Oumachigui A. *Indian J Pediatr*. 1996; 63:357–361.
21. Bhat B.V., Ravikumara M. *Indian J Matern Child Health*. 1996; 7:31–33.
22. Rajasekar S., Bhat B.V., Beliath A.J., Ratnakar C. *Indian J Pediatr*. 1996; 63:511–516.
23. Hoffman J.I.E., "The global burden of congenital heart disease," *Cardiovascular Journal of Africa*, 2013; 24(4): 141–145.
24. Saxena A., "Congenital heart disease in India: a status report," *Indian Journal of Pediatrics*, 2005; 72(7): 595–598.
25. Verma M., "Epidemiology of congenital heart disease in India," *Indian Pediatrics*, 2019; 56(2): 97–100.
26. Wu W., "Prevalence of congenital heart disease in Asia: a systematic review," *BMC Pediatrics*, 2013; 13(1): 48–56.
27. Rubia A., "Gender disparity in congenital heart disease: A retrospective study," *Journal of Pediatric Cardiology*, 2012; 24(2): 118–123.
28. Tandon S., "Socioeconomic profile of children with congenital heart defects," *Indian Pediatrics*, 2010; 47(9): 759–762.

29. Vaidyanathan B., “Gender differences in the diagnosis of CHD,” *Indian Heart Journal*, 2008; 60(6): 455–459.
30. Smitha R., “Clinical profile of children with CHD in South India,” *Indian Journal of Clinical Pediatrics*, 2011; 18(3): 207–211.
31. Kapoor R., “Incidence of congenital heart disease in rural India,” *Indian Journal of Pediatrics*, 2006; 73(2): 143–146.
32. Mishra A., “Epidemiological profile of CHD in children,” *Journal of Indian Medical Association*, 2009; 107(5): 259–261.
33. Jatay S., “Pattern of congenital heart defects in North India,” *Indian Journal of Cardiology*, 2010; 12(1): 33–37.
34. Abqari S., “Profile of congenital heart disease in Kashmir Valley,” *Indian Heart Journal*, 2015; 67(4): 375–379.
35. Agha M.M., “CHD in children from low socioeconomic background,” *Pediatric Cardiology*, 2014; 35(6): 1061–1066.
36. Kliegman R.M., “Nelson Textbook of Pediatrics,” *Elsevier*, 2019; 21st ed: 2235–2237.
37. Oyen N., “Familial recurrence of CHD,” *Circulation*, 2009; 120(4): 295–301.
38. Ellesoe G.S., “Recurrence risk of CHD in siblings,” *International Journal of Cardiology*, 2010; 140(3): 293–296.
39. Nora J.J., “Genetic factors in CHD,” *Pediatric Clinics of North America*, 1998; 45(1): 1–10.
40. Bensemlali M., “Prevalence of extracardiac anomalies in CHD fetuses,” *Prenatal Diagnosis*, 2016; 36(11): 1040–1046.
41. Best K.E., “Maternal age and risk of CHD,” *Birth Defects Research*, 2012; 94(10): 804–811.
42. Luo Y.L., “Risk factors for CHD in younger mothers,” *BMC Pediatrics*, 2018; 18(1): 300–306.
43. Gnanalingam M.G., “Parental consanguinity in CHD,” *Annals of Pediatric Cardiology*, 2017; 10(3): 251–256.
44. Chehab G., “Consanguinity and CHD in Lebanon,” *Journal of Genetic Counseling*, 2015; 24(5): 772–778.
45. Rahman M., “Birth order and child nutrition in Bangladesh,” *BMC Pediatrics*, 2013; 13(1): 124–129.
46. Howell E.M., “Birth order and child outcomes in Africa,” *Journal of Biosocial Science*, 2010; 42(3): 367–380.
47. Steurer A.M., “CHD risk in preterm infants,” *Pediatrics*, 2019; 144(1): e20182268.
48. Ramakrishnan A., “Maternal health factors and CHD,” *Journal of Perinatology*, 2015; 35(10): 748–752.
49. Boyd P.A., “Risk factors for congenital anomalies,” *European Journal of Obstetrics & Gynecology*, 2010; 149(1): 61–67.
50. Tabib S.M., “Maternal diabetes and CHD risk,” *Iranian Journal of Pediatrics*, 2016; 26(2): e2789.
51. Muhammed A., “Gestational hypertension and CHD,” *Journal of Obstetrics and Gynaecology*, 2017; 37(1): 49–53.
52. Hunter E., “Infections in pregnancy and CHD,” *Archives of Disease in Childhood*, 2014; 99(3): 250–254.
53. Pradat P., “Prevalence of extracardiac anomalies in CHD,” *Pediatrics*, 2003; 111(1): 84–89.
54. Bosi G., “CHD and extracardiac malformations in Italy,” *Cardiology in the Young*, 2003; 13(5): 436–443.
55. Julian C., “CHD and syndromes in Chilean children,” *RevistaChilena de Pediatría*, 2008; 79(3): 243–249.
56. Abdullah M., “CHD with extracardiac anomalies in Saudi Arabia,” *Annals of Pediatric Cardiology*, 2010; 3(2): 113–117.

57. Egbe A., “Prevalence of extracardiac anomalies in CHD patients,” *Mayo Clinic Proceedings*, 2014; 89(10): 1330–1338.
58. Tennstedt C., “CHD necropsy findings,” *Pathology Research and Practice*, 2005; 201(7): 509–515.
59. Freeman S.B., “CHD in Down syndrome,” *Journal of Pediatrics*, 2008; 153(6): 807–813.
60. Greenwood R.D., “Extracardiac malformations in CHD,” *Pediatrics*, 1976; 58(4): 561–567.
61. Wallgren E.I., “Associated anomalies in CHD,” *Pediatric Cardiology*, 1975; 4(3): 181–186.
62. Gallo M.C., “Urinary anomalies in CHD,” *Urology*, 1980; 16(5): 512–517.
63. Touloukian R.J., “Gastrointestinal obstruction and CHD,” *Surgery*, 1977; 82(2): 272–276.
64. Fonkalsrud E.W., “Duodenal obstruction and CHD,” *Archives of Surgery*, 1976; 111(8): 893–895.
65. Teixeira F.A., “Anorectal malformations and CHD,” *Pediatric Surgery International*, 1998; 14(1-2): 22–25.