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Maternal Prenatal Risk Factors and Congenital Heart Disease: a Preliminary Study

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Abstract:
Identifying non-maternal hereditary risk factors of congenital heart disease (CHD) will allow for early detection, perinatal management, prevention, and intervention strategies. Reducing these factors may help decrease perinatal morbidity and improve quality of life. We studied maternal risk factors associated with CHD. A retrospective study was conducted among pregnant mothers referred to the pediatric cardiology clinic at RSAB Harapan Kita from January 2013 to December 2024. Demographics, non-hereditary risk factors, and occurrence of CHD were collected from March 2024 to late December 2024. Regression analysis with IBM SPSS version 20 was used to estimate the odds ratio (OR) and 95% confidence interval (CI). Significance was set as p<0.05. A total of 350 pregnant women aged 18–45 years and 361 fetuses were included. Fetal and perinatal echocardiography revealed CHD in 242 (67%), while 119 (33%) were normal. Significant maternal risk factors for CHD were age >35 year (OR2.58;95%CI1.38–4.82;p=0.01), grand multiparity (OR8.04;95%CI1.05–61.34;p=0.02), polyhydramnios (OR 4.25;95%CI0.97–18.71;p=0.04), and hypoalbuminemia (OR 7.50;95% CI0.98–56.48; p=0.03). Maternal age>35 years, grand multipara, polyhydramnios, and hypoalbuminemia were positively associated with CHD. This association might be used to predict the suspicion of perinatal CHD and to guide appropriate management.

Keywords: *CHD, maternal, prenatal, risk factor*

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INTRODUCTION

Congenital heart diseases (CHD) is the most common congenital anomalies, with an estimated prevalence of 8 in 1000 live births. CHD occurs as a result of abnormal embryogenesis of the heart and is associated with significant mortality and morbidity. The damage to the heart is irreversible due to a lack of regeneration potential, and usually, newborns with CHD may require surgical intervention. Studying heart developmental biology is essential not only in understanding the mechanisms and pathogenesis of CHD but also in providing us with insight into developing new preventive and treatment methods (Suluba et al., 2020).

The etiology of CHD is still unclear. Both genetic and environmental factors might play a role in the pathogenesis of the disease. Recently, cardiac transcription factors, cardiac-specific genes, and signaling pathways responsible for early cardiac morphogenesis have been extensively studied in both

human and animal experiments, but much remains to be desired. There was some research which have also shown non-hereditary risk factors such as rubella infection, teratogens, maternal age, diabetes mellitus, and abnormal hemodynamics in causing CHDs.

These etiological factors raise questions about the multifactorial etiology of CHDs. It is therefore important to further explore research aimed at identifying the causes of CHDs. Identifying causal factors will enable us to plan intervention strategies and mitigate the consequences of CHDs. Additionally, it discusses crucial signaling pathways involved in early cardiac morphogenesis. CHD is a general term for a structural or functional defect of the heart that is present at birth (Kalisch-Smith et al., 2020). Both genetic and environmental factors have been implicated to play a role in the pathogenesis of the diseases and the aetiology of CHD (Rachamadugu SI et al.,2022; Suluba et al., 2020).

The advanced genetic and genomic technologies have enabled the identification 100 genes associated with CHD, but only one-third of CHD cases have been shown to have a simple genetic cause. This is because CHD can also be caused by oligogenic factors, environmental exposures, or interactions between genes and the environment (Kalisch-Smith et al., 2020). A significant proportion of CHD cases are likely to be caused by environmental risk factors; however, it has been relatively difficult to clearly identify specific factors or their mechanism of action. Although the embryonic consequences of maternal rubella infection and thalidomide use were readily identified through observation and anecdotal reports, large-scale epidemiological studies have been required to identify other potential risk factors (Kalisch-Smith et al., 2020). This study, therefore, puts forward a non-genetic cause of CHD.

To our knowledge, it is predicted that among the 270 million Indonesian population may be 50 thousand new cases of CHD every year. The reported prevalence of CHD in our daily practice seems to have dramatically increased in recent decades, but this is most likely because of better diagnostic procedures, especially echocardiography. Commonly identified risk factors for CHD include a multivitamin and folic acid-deficient diet during pregnancy, maternal diabetes, febrile illnesses, consanguinity, systemic lupus erythematosus (SLE) in the mother, bad obstetric history (including previous history of abortions and stillbirths), advanced paternal/maternal age, and maternal drug exposure (Abqari et al., 2016).

CHD is the most common congenital anomaly among all birth defects, representing a major global health problem. Twenty-eight percent of all major congenital anomalies consist of heart defects (Abqari et al., 2016). The aetiology of the different distribution of CHD among genders is still under investigation. A recent meta-analysis reported that worldwide birth prevalence in children (Pugnaloni et al., 2023). The highest *mortality* risk was found during the *first* 4 years of *life* in patients with CHD. There were improvements in diagnostic procedures, catheter interventions, and several surgical innovations, such as the surgical treatment of aortic coarctation; repair of atrioventricular septal defects; Mustard and Senning atrial corrections; the Rastelli procedure; the arterial switch; and the creation of single-ventricle Fontan circulation. Despite this improvement, the mortality during the first 4 years of life among patients with CHD remains comparatively high, making the need for further improvement in pediatric care persist.

Advances in pediatric cardiovascular surgery and cardiac interventional catheterization since the new millennium have shown improved outcomes in selected groups of patients with CHD. In addition, the antenatal diagnosis of CHD s has been introduced, and currently 37% of all CHD is diagnosed prenatally. However, it is unclear whether recent developments have affected the survival of pediatric patients with CHD over the past decade (Mandalenakis et al., 2020).

The above improvements in cardiovascular care since the 1970s and 1980s have resulted in improved survival for children with CHD. Further advances in the past 2 decades have not yet resulted in increased survival for patients with CHD in general nor for specific lesion groups of patients. Clearly, there is still room for improvement in survival and development of care in patients with the most complex CHD groups, where mortality is still high, and 10% to 20% of those born die before becoming adults. There is a sign of optimized surgical procedures, interventional techniques, and diagnostic improvements, but where no further improvement, given today's technology and knowledge, may be difficult to obtain. Improvement in a case with antenatal diagnostics. There is an indication for

improving surgical support techniques and myocardial and cerebral protection to further increase the dramatic improvement in CHD care over the last decades of the 19th century (Mandalenakis et al., 2020).

Early detection as well as prevention of CHDs is very important. It is therefore important to undertake research aimed at identifying the causes of CHD. Identifying causal factors will enable us to make early diagnoses, plan intervention strategies, and mitigate the consequences of CHD (Suluba et al., 2020).

We investigated the 10th most common of maternal non-hereditary risk factors for CHD and maternal morbidity in the prenatal period by conducting fetal echocardiography. As we know, fetal echocardiography is a diagnostic method that investigates cardiac anatomy, function, and rhythm during the antenatal period. It helps to detect the antenatal CHD and rhythm problems. We believe that the diagnosis of CHD in the antenatal period increases the chances of survival of babies with CHD. The presence of antenatal diagnosis was found to be one of the factors decreasing mortality, especially in patients with hypoplastic left heart syndrome. The presence of antenatal diagnosis is effective in decreasing morbidity and mortality after birth and is an important diagnostic tool in the decision to terminate the pregnancy. We believe that the maternal non-hereditary risk factors identified in this study may reflect those in the general maternal population. This study may complete the non-hereditary risk factors that were not assessed during the prenatal period. We hope this study may help increase early diagnosis in primary health care.

METHODS

A retrospective study was conducted among pregnant mothers referred to the pediatric cardiology clinic at RSAB Harapan Kita from January 2013 to October 2024. We collected data on demographics, maternal non-hereditary risk factors, fetal CHD, and early neonatal outcomes from March 2024 to December 2024. Fetal and neonatal heart screening was performed in accordance with the American Institute of Ultrasound Medicine and American Society of Echocardiography (AIUM, 2020; Moon-Grady et al., 2023).

Maternal demography, such as the mother's age, parity, gestational age, and non-hereditary risk factors during pregnancy, was documented. Maternal non-hereditary risk factors such as maternal age, polyhydramnios, diabetes mellitus, hypertension, fever in the first trimester, CHD history on previous pregnancy, consumption of epileptic drugs, smoking, and alcohol consumption were tabulated. Maternal non-hereditary risk factors and fetal extracardiac anomalies were diagnosed by an obstetrician and a gynecologist.

Diagnosis of CHD was confirmed with trans thoracal echocardiography during the neonatal period by a pediatric cardiologist. Neonates with no CHD were classified as the control group. This study was approved by the Institutional Board Research RSAB Harapan Kita IRB/06/02/ETIK/2021. Pearson and Spearman tests were performed in SPSS 20.0. We analyzed risk factors using IBM SPSS version 27, calculating odds ratios (ORs) and 95% confidence intervals (CIs). Significance was set as $p<0.05$ (Dahlan, 2020, 2024).

RESULTS

We evaluated 350 pregnant mothers aged 29.7 ± 4.9 years with a gestational age of 33.2 ± 4.9 weeks; of these, 312 (96.9%) were singleton gestations, 4 (1.3%) were duplet gestations, and 2 (0.6%) were triplet gestations. Among them were 3 (0.9%) with ages < 21 years and 72 (24.2%) subjects aged> 35 years. There were 138 (42.5%) first gravid, 162 (48.7%) second and third gravid, 17 (4.7%) fourth gravid, and 15 (4.1%) fifth gravid.

We found there were 361 neonates in the perinatal period, and transthoracic echocardiography confirmed the fetal final diagnosis of CHD. There were 119 (33%) with PFO and non-significant PDA that closed spontaneously within 7 days of life, classified as the control group, and 242 (67%) with CHD (Table 1).

Table 1. Maternal, fetal, and neonatal characteristics

Characteristic	Variables	Result x ± SB ; Median (min-max); n (%)
Mother (n=350)	Age (year)	29.7 ± 4.9
	Gestation age (weeks)	33.2 ± 4.1
	non hereditary risk factors (%)	119 (33)
Fetal and Neonate (n=361)	Female: Male	189 (52.4): 172 (47,6)
	Normal Heart	119 (33)
	CHD	242 (67)

We noted that the 10th most common maternal non-hereditary risk factors of CHD consist of age > 35 years, polyhydramnios, hypoalbuminemia, grand multipara, history of CHD, Hb <12 g/dL, oligohydramnios, hypothyroid, autoimmune, and diabetes mellitus (Table 2).

Table 2. Maternal morbidity during pregnancy

Maternal Variables	n (%)
Age > 35 years	74 (21.2)
Polyhydramnios	19 (5.4)
hypoalbuminemia (albumin < 3,8 g/dL)	16 (4.6)
Grand multipara (pregnancy >5 times)	15 (4.3)
history of CHD, previous pregnancy	13 (3.7)
Hb < 12 g/dL	12 (3.4)
Oligohydramnios	11(3.1)
Autoimmune	5 (1.4)
Hypothyroid	8 (2.3)
History of infection in the first trimester	3 (0.9)

We confirmed the prenatal CHD diagnosis during the neonatal period with trans thoracal echocardiography on the first week of life. We noted the final diagnosis of CHD and classified to acyanotic CHD in 122 (54.9%) neonates, cyanotic in 98 (44,1%), and 31 (15.8%) critical cyanotic heart disease (CCHD). The most common acyanotic CHD were VSD, ASD, CAVSD, and PDA. While the most common cyanotic CHD were Ebstein anomaly, tetralogy of Fallot, CAVSD with outlet variation, Hypoplastic left heart syndrome (HLHS), and tricuspid atresia (Table 3).

Table 3. Distribution of fetal and neonatal CHD

Fetal and neonatal CHD Diagnosis	n (%)
Ventricular septal defect (VSD)	76 (21)
Atrial septal defect (ASD)	67 (18.5)
Ebstein anomaly	39 (10.9)
Common atrioventricular septal defect (CAVSD)	28 (7.7)
Tetralogy of Fallot	27 (7,4)
Patent ductus arteriosus	18 (5)
CAVSD with outlet variation	13 (3,7)
Hypoplastic left heart syndrome (HLHS)	12 (3.2)
Tricuspid atresia	12 (3.2)
Double outlet right ventricle	10 (2.8)
Pulmonary stenosis	9 (2.7)
Smallish left ventricle	3 (0.9)
Coarctation of aorta	2 (0.5)
Mitral atresia	2 (0.5)
Right ventricle hypoplasia	2 (0.5)
Right isomerism	2 (0.5)
Left isomerism	2 (0.5)

Maternal risk factors were identified in 119 cases (33%). Significant maternal risk factors for CHD were age >35 years (OR 2.58, 95% CI 1.38–4.82; p=0.01), grand multiparity (OR 8.04,95% CI 1.05–61.34; p=0.02), polyhydramnios (OR 4.25, 95% CI 0.97–18.71; p=0.04), and hypoalbuminemia (OR 7.50, 95% CI 0.98–56.48; p=0.03). This study did not find an association between maternal anemia, oligohydramnios, history of congenital heart disease in previous pregnancy, autoimmune, hypothyroid, or history of infection in the first trimester (Table 4).

Table 4. Association of maternal risk factors with CHD

Maternal Variables	CHD in neonate period		OR	*P* value	95% CI
	Yes	No			
Age (Year)					
> 35	61 (82.4%)	13 (17.6.%)	2.58	0.03*	1.35–4.94
< 35	178(64.5 %)	98 (35.5%)			
Grand multipara					
Yes	14 (93.3.1)	1 (6.7%)	6,86	0.04*	0.89–52.72
No	225 (67.2%)	110 (32.8%)			
Hypoalbumin					
Yes	15 (93.8%)	1 (6.3)	7.37	0.03*	0.96–56.48
No	224 (67.1%)	110 (32.9%)			
Anemia					
Yes	9 (75%)	3 (25%)	1.4	0.75	0.37–5.31
No	230 (68%)	108 (32%)			
Polyhydramnios					
Yes	17 (89.5%)	2 (10,5 %)	4.17	0.04*	0.95–18.39
No	222(67.1%)	109 (32.9%)			
Oligohydramnios					
Yes	8 (72.7%)	3 (27.3%)	1.25	1.00	0.32 – 4.79
No	239 (68.3%)	111 (31.7%)			
History of CHD in previous pregnancy					
Yes	11(84.6%)	2 (15.4%)	2.63	0.24	0.57–12.07
No	228 (67.7%)	109 (32.3%)			
Autoimmune					
Yes	3 (60%)	2 (40%)	0.69	0.05	0.114-4.21
No	236 (68.4%)	109 (31.6%)			
Hypothyroid					
Yes	5 (62.5%)	3 (37.5%)	0.77	0.71	0.18 – 3.28
No	234 (68.4%)	108 (31.6%)			
History of infection on first trimester					
Yes	3 (100%)	0 (0.0%)	1.47	0.55	1.37 –1.58
No	236 (68%)	111 (32%)			

DISCUSSION

Maternal risk factors of CHD have been studied and published by many authors (Giraldo-Grueso et al., 2020; Jenkins et al., 2007). Paternal risks may contribute to the occurrence of CHD. This study reviewed pregnant mothers who were referred to the pediatric cardiology outpatient clinic for fetal cardiac anatomy evaluation. As far as we are aware, our study is among the first in Indonesia to evaluate maternal non-hereditary risk factors associated with CHD. We believed that factors which associated with CHD are affected by the social economy, education, and social cultural with very different among regions or countries. A hospital-based study may yield different results than a population-based study. We hope this study might be used in daily practice to early detect CHD by knowing non-hereditary maternal risk factors. Furthermore, we hope it may enhance perinatal CHD management and may play

a role in decreasing perinatal morbidity and mortality.

We found that most mothers were referred to our hospital over the last three semesters. It could be understood since most of them had initially been suspected to have fetal CHD and had been previously referred to several health centers. Generally, subjects were also carefully screened for CHD by others feto maternal expert and finally were referred to our hospital. As far as we know study fetal congenital heart defects and maternal risk factors are not available in Indonesia. The ultrasonic color Doppler imaging study revealed a relatively common prevalence of CHD (Cao et al., 2022).

Fetal echocardiography is important as it allows not only improved counseling of families after a prenatal diagnosis of CHD, but also for proper perinatal management, as the neonate with a significant cardiac lesion will benefit from delivery at a tertiary care center where the expertise of pediatric cardiologists and cardiac surgeons. Prenatal detection improves perinatal outcomes before surgery, resulting in lower morbidity and mortality. The high detection rates are explained by the thoroughly organized national screening program with well-defined ultrasound protocols. Uniform training and quality assessments for fetal, maternal, and pediatric cardiology doctors warrant a quality level not restricted to urban areas, as this cohort includes large rural areas as well (Gupta et al., 2023).

It has been known that significantly maternal risk factor associated with CHD was low maternal education. Active and passive smoking in pregnancy, obesity, and maternal age at pregnancy were not associated with CHD (Christine et al., 2014). Another study revealed that gestational diabetes mellitus (OR: 5,27; 95% CI 0,60-46,23; p 0,21), maternal rubella infection (uninterpreted), advanced maternal age (OR: 3,60; CI 95% 1,34-9,64; p 0,01), and multifetal pregnancy (OR: 1; 95% CI 0,20-5,11; p 1). The multivariable analysis revealed that aOR for gestational diabetes mellitus was 6,34 with 95% CI 0,72-55,82 (p 0,10) and the aOR for advanced maternal age was 3,59 with 95% CI 1,33 9,71 (p 0,01) (Budiarto et al., 2021).

Further, the result of our study is related to Alfarhan et al study. The significant risk factors for the development of transposition of the great arteries include increasing maternal age and parity, gestational diabetes, family history of congenital cardiac anomalies, and first-degree consanguineous marriages. These factors increased the risk by at least 2-fold (Alfarhan et al., 2020).

Maternal age has been linked in the literature with the risk of development of congenital malformation in the fetus. Advanced maternal age was associated with higher odds ratios compared with the control group. Advancing maternal age showed a trend toward increased risk of TGA in the perinatal period. Other studies have shown that maternal age > 35 years was noted to put infants at increased risk of CHD, while infants born to younger mothers had a lower risk (Alfarhan et al., 2020). Further, a systematic population-based echocardiographic study of infants showed that maternal age> 40 years was also associated with smaller systolic and diastolic LV diameters. However, the long-term effects are unknown (Nørregaard et al., 2023). Mothers who are older than 35 presented mostly with ventricular septal defects (VSD) and patent ductus arteriosus (PDA) (Hashim et al., 2020).

Grand multiparity remains a risk factor for a wide range of obstetric complications, especially in developing countries. Grand multiparity has been shown to increase the risks of medical and obstetric complications during pregnancies (Dasa et al., 2022).

This study showed the association of grand multipara with CHD, and it was in relation to another study. Parity as well as mother's origin and father's age were factors associated with the occurrence of CHD (Segbedji et al., 2023). Indirect non-hereditary factors such as the father's age, were evaluated in this study.

The association of polyhydramnios and CHD in this study was also noted by a previous study. Cardiovascular malformations were significantly associated with polyhydramnios. Although in some of the cardiovascular malformations, the association rate with polyhydramnios was high (AVSD, double outlet right ventricle, tetralogy of Fallot). The association of polyhydramnios and CHD was a moderate association rate (19.7%), while the association with oligohydramnios was 8.57% (Simonyi et al., 2021).

Hypoalbuminemia in this study may reflect maternal nutritional status and was not congenital hypoalbuminemia. Maternal nutritional status has been highlighted as a need for in-depth research in

the emerging area of maternal nutritional epigenetics and CHD. It will summarize and benefit future research on nutrition as a modifiable environmental factor to decrease the incidence of CHD (Joshi et al., 2020). In addition to maternal and embryonic exposure to teratogens, there is also evidence that reduced maternal levels of essential nutrients can also increase the risk of CHD in her offspring. However, in many cases, these observations have been made in animal models, and as yet, there is little conclusive evidence that these factors are also relevant in humans (Kalisch-Smith et al., 2020).

A low vitamin A diet in rodent models during pregnancy causes highly penetrant heart defects and AAAs. DNA methylation. It has all these finding may not reflect CHD in the population. However, we believe the distribution of CHD in this study, reflected the referral CHD characteristic to a tertiary referral hospital in other provinces in Indonesia. We found that CCHD was 30% among cyanotic CHD. This is a high incidence, which might be explained as our hospital is a tertiary referral hospital for both feto maternal and pediatric CHD services. It should be noted that early pulse oximetry screening, 1 day after the baby is born, is a must. This CCHD incidence was similar to the Ruan et al study. They found among a total of 5024 subjects, total fetuses with CHD were 875, and critical CHDs account for 27%, of which Tetralogy of Fallot is the most (7.1%), followed by coarctation of the aorta (4.0%), double-outlet right ventricle (2.9%) (Ruan et al., 2023). Our study revealed that among critical CHDs, account for 30% of which Ebstein anomaly, hypoplastic left heart syndrome, and double outlet right ventricle with outlet variation. It can also be explained that the CCHD above is slightly easier during an early fetal echocardiography procedure on a four-chamber view.

We did not find an association between maternal anemia, oligohydramnios, history of congenital heart disease in previous pregnancy, autoimmune, hypothyroid, or history of infection in the first trimester. The association of these non-hereditary risk factors has been studied by other studies with large numbers of subjects. A study found 2.776 pregnant women with diagnosed CHD and found that maternal anemia in early pregnancy increased the risk of offspring (Nair et al., 2025).

The incidence of maternal anemia in Indonesia (48.9%), which exceeds the WHO standard of >40%, signifies a severe public health concern that requires immediate attention and intervention. Consuming iron-rich meals and supplements with regular antenatal care visits in early pregnancy reduces the maternal anemia rate. A study aimed to determine the relationship between the level of knowledge and behavior during pregnancy and the incidence of anemia (Futihandayani et al., 2025).

Knowledge and maternal behavior are the most important aspects of anemia prevention strategies. Although the level of knowledge was not significantly associated with the incidence of anemia, women who were found in the level of good (33%) and fair knowledge (55%) showed good behavior for its prevention. There was a statistically significant association between behavior during pregnancy and the incidence of anemia (p-value = 0.025). Iron supplementation emerged as a critical factor in preventing anemia in pregnancy (Futihandayani et al., 2025). A previous study has found that a high frequency of CHD was observed in infants of 100 diabetic mothers. CHD was diagnosed in 71% of neonates. The most frequent types were ventricular septal defect (32.39%), patent ductus arteriosus (35.21%), and atrial septal defect (19.72%). The frequency of CHD was higher among older mothers (Sial et al., 2024). Among 1,014,448 singletons, we found that maternal hypothyroidism is associated with increased risk of CHD in offspring with a hazard ratio (HR) 1.23 (95% CI 1.12-1.35). Offspring born to mothers with hypothyroidism had an increased risk of CHD and several subcategories, including hypertension, arrhythmia, and acute myocardial infarction in offspring (Miao et al., 2021).

Current research has shown that many factors are associated with an increased risk of CHD in the prenatal period, including genetic and maternal or fetal factors. Race is also an associated factor of CHD. The reason for this might be that the prevalence of CHD is 8.98 per 1000 live births in China, higher than the global level. CHD is also one of the leading causes of morbidity and mortality in the perinatal and infant periods. In addition, several studies have shown that race is associated with CHD and have concluded the effect of race on differences in the prevalence of CHD. Every race has its own characteristics related to CHD, maybe influenced by the differences in socioeconomic status and racial disparities. So there is a need for such research data from more racial groups to enrich this field (Joshi et al., 2020).

This data can be an early effort to detect CHD congenitally in both fetal and newborn. An increased of aged > 35 years, polyhydramnios, grand multipara, and hypoalbuminemia were significantly associated with CHD. This association might be useful to early identify CHD to increase management and premarriage and prenatal prevention. We did not find any other maternal non-hereditary risk factor which had association with CHD.

This study ought to be continued by assessing fetal, neonatal risk factors, and neonatal outcome with more subjects. Further, we may have knowledge of the comprehensive risk factors that might be used to perform a CHD national preventive program. This challenging effort might help us to decrease the incidence of CHD. Further study with a larger number of subjects ought to be conducted to evaluate independent maternal and fetal risk factors and neonatal outcomes.

CONCLUSION

Fetal echocardiography is important as it allows both early CHD detection, which might result in decreasing both perinatal and infant morbidity and mortality. The risk factors in this study underscore the need for primary health services and midwives to take precautions against CHD during daily practice under limited health services in Indonesia, and to conduct proper management.

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AUTHOR CONTRIBUTION

Conceptualization	: SR
Methodology	: SR
Software	: NMV, SDL, GA, IA,
Formal analysis	:SR, NMV, SDL, GA, IA,
Investigation	:NSP, DD, AK, RDKH, AW
Resources	:NSP, DD, AK,
Data Curation	:SR, NMV, SDL, GA, IA, ADW, NSP, DD, AK, RDKH, AW
Writing - Original Draft	:SR, NMV, SDL, GA, IA, ADW, NSP, DD, AK, RDKH, AW
Writing - Review & Editing	:SR, NMV, SDL, GA, IA, ADW, NSP, DD, AK, RDKH, AW

ETHICAL APPROVAL AND CONSENT

This study was approved by the Institutional Board of Research RSAB Harapan Kita IRB/06/02/ETIK/2021. The objectives and procedures of this study were explained to the respondents, and they were able to withdraw from the research process. All respondents voluntarily participated in this research and signed the informed consent.

FUNDING

This study received no external funding

CONFLICT OF INTEREST

The authors hereby declare that there's no conflict of interest in this study, either to any institutions or individuals.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are not publicly available due to privacy or ethical restrictions. However, they are available from the corresponding author on reasonable request and with permission from Rumah Sakit Anak dan Bunda Directional Board.

PROTOCOL REGISTRATION

This study was not registered.

REFERENCES

Abqari, S., Gupta, A., Shahab, T., Rabbani, M. U., Ali, S. M., & Firdaus, U. (2016). Profile and risk factors for congenital heart defects: A study in a tertiary care hospital. *Annals of Pediatric Cardiology*, *9*(3), 216–221. https://doi.org/10.4103/0974-2069.189119

Alfarhan, A., Alquayt, M., Alshalhoub, M., Alnahdi, M. A., Masuadi, E., & Alhabshan, F. (2020). Risk factors for transposition of the great arteries in Saudi population. *Saudi Medical Journal*, *41*(10), 1054–1062. https://doi.org/10.15537/SMJ.2020.10.25418

Budiarto, A., Murni, I. K., & Noormanto. (2021). *Faktor Risiko yang Berhubungan dengan Penyakit Jantung Bawaan pada Pasien Anak di RSUP dr. Sardjito Yogyakarta Tahun 2021*. https://etd.repository.ugm.ac.id/penelitian/detail/208756

Cao, Y., Huang, R., Kong, R., Li, H., Zhang, H., Li, Y., Liang, L., Xiong, D., Han, S., Zhou, L., Guo, J., Dai, G., Meng, M., Lou, H., Hou, Z., & Jiang, L. (2022). Prevalence and risk factors for congenital heart defects among children in the Multi-Ethnic Yunnan Region of China. *Translational Pediatrics*, *11*(6), 813–824. https://doi.org/10.21037/tp-21-371

Christine, A., Putra, S., Dwipoerwantoro, P. G., Alatas, H., Widodo, D. P., & Sari, T. T. (2014). *Maternal risk factors and characteristics in pediatric congenital heart defects* [Universitas Indonesia]. https://lib.ui.ac.id/detail?id=20365705&lokasi=lokal

Dahlan, M. (2020). *Statistik Untuk Kedokteran dan Kesehatan: Deskriptif, Bivariat, dan Multivariat* (6th ed., Vol. 1). CV. Metode Multiaksis Sopiyudin Dahlan (Metode MSD).

Dahlan, M. (2024). *Analisis Multivariat Regresi Logistik* (2nd ed.). Epidemiologi Indonesia.

Dasa, T. T., Okunlola, M. A., & Dessie, Y. (2022). Effect of grand multiparity on adverse maternal outcomes: A prospective cohort study. *Frontiers in Public Health*, *10*. https://doi.org/10.3389/fpubh.2022.959633

Futihandayani, A., Siagian, I., & Febriani, F. (2025). Maternal Knowledge and Behavior as Prevention of Anemia in Pregnancy: A Health Facility-Based Cross-Sectional Study Design. *Indonesian Journal of Obstetrics & Gynecology Science*, *8*(1), 42. https://doi.org/10.24198/obgynia.v8i1.800

Garcia Philemon Satingo Segbedji, G., Bagnan Tossa, L., Seidou, H., Sedjro Clotaire Romeo Houegban, A., Enianloko Tchiakpe, N., Aristide Medard Amoussou, C., Seraphin Gbenou, A., & Armand Fiogbe, M. (2023). Factors associated with congenital differences in neonates in southern Benin: a case-control study. *J Pediatr Neonatal Care*, *13*(3), 190–193. https://doi.org/10.15406/jpnc.2023.13.00515

Giraldo-Grueso, M., Zarante, I., Mejía-Grueso, A., & Gracia, G. (2020). Risk factors for congenital heart disease: A case-control study. *Revista Colombiana de Cardiologia*, *27*(4), 324–329. https://doi.org/10.1016/j.rccar.2019.11.008

Gupta, T., Ganjoo, S., Kaul, V., Makhija, R. K., Mishra, S., & Sareen, S. (2023). Routine fetal echocardiography for detection of congenital heart disease-mandatory or an optional tool? *International Journal of Contemporary Pediatrics*, *10*(4), 453–457. https://doi.org/10.18203/2349-3291.ijcp20230660

Hashim, S. T., Alamri, R. A., Bakraa, R., Rawas, R., Farahat, F., & Waggass, R. (2020). The Association Between Maternal Age and the Prevalence of Congenital Heart Disease in Newborns from 2016 to 2018 in Single Cardiac Center in Jeddah, Saudi Arabia. *Cureus*. https://doi.org/10.7759/cureus.7463

Jenkins, K. J., Correa, A., Feinstein, J. A., Botto, L., Britt, A. E., Daniels, S. R., Elixson, M., Warnes, C. A., & Webb, C. L. (2007). Noninherited risk factors and congenital cardiovascular defects: Current knowledge - A scientific statement from the American Heart Association Council on Cardiovascular Disease in the Young. *Circulation*, *115*(23), 2995–3014. https://doi.org/10.1161/CIRCULATIONAHA.106.183216

Joshi, R. O., Chellappan, S., & Kukshal, P. (2020). Exploring the Role of Maternal Nutritional Epigenetics in Congenital Heart Disease. In *Current Developments in Nutrition* (Vol. 4, Issue 11). Oxford University Press. https://doi.org/10.1093/cdn/nzaa166

Kalisch-Smith, J. I., Ved, N., & Sparrow, D. B. (2020). Environmental risk factors for congenital heart disease. *Cold Spring Harbor Perspectives in Biology*, *12*(3). https://doi.org/10.1101/cshperspect.a037234

Mandalenakis, Z., Giang, K. W., Eriksson, P., Liden, H., Synnergren, M., Wåhlander, H., Fedchenko, M., Rosengren, A., & Dellborg, M. (2020). Survival in children with congenital heart disease: Have we reached a peak at 97%? *Journal of the American Heart Association*, *9*(22). https://doi.org/10.1161/JAHA.120.017704

Miao, M., Liu, H., Yuan, W., Madsen, N., Yu, Y., László, K. D., Liang, H., Ji, H., & Li, J. (2021). Association of Maternal Hypothyroidism With Cardiovascular Diseases in the Offspring. *Frontiers in Endocrinology*, *12*. https://doi.org/10.3389/fendo.2021.739629

Nair, M., Drakesmith, C. W., Smith, M., Bankhead, C. R., & Sparrow, D. B. (2025). Maternal Anaemia and Congenital Heart Disease in Offspring: A Case–Control Study Using Linked Electronic Health Records in the United Kingdom. *BJOG: An International Journal of Obstetrics and Gynaecology*. https://doi.org/10.1111/1471-0528.18150

Nørregaard, M. M. O., Basit, S., Sillesen, A. S., Raja, A. A., Jørgensen, F. S., Iversen, K. K., Bundgaard, H., Boyd, H. A., & Vøgg, R. O. B. (2023). Impact of maternal age and body mass index on the structure and function of the heart in newborns: a Copenhagen Baby Heart Study. *BMC Medicine*, *21*(1). https://doi.org/10.1186/s12916-023-03207-9

Pugnaloni, F., Felici, A., Corno, A. F., Marino, B., Versacci, P., & Putotto, C. (2023). Gender differences in congenital heart defects: a narrative review. In *Translational Pediatrics* (Vol. 12, Issue 9, pp. 1753–1764). AME Publishing Company. https://doi.org/10.21037/tp-23-260

Ruan, Y., Xie, Z., Liu, X., & He, Y. (2023). Associated factors for prenatally diagnosed fetal congenital heart diseases. *BMC Cardiovascular Disorders*, *23*(1). https://doi.org/10.1186/s12872-022-02981-3

Sial, Z., Raheel, A., Jamshaid, M., Noor, S., Aslam, M. W., Nawaz, Z., & Usman, M. (2024). Impact of Maternal Diabetes on Maternal Diabetes on the Prevalence and Pattern of Congenital Heart Diseases in Infant. *Journal of Population and Therapeutics and Clinical Pharmacology*. https://doi.org/10.53555/jptcp.v31i5.6363

Simonyi, A., Eros, F. R., Hajdu, J., & Beke, A. (2021). Effectiveness of fetal ultrasound diagnostics in cardiac malformations and association with polyhydramnios and oligohydramnios. *Quantitative Imaging in Medicine and Surgery*, *11*(7), 2994–3004. https://doi.org/10.21037/qims-20-823

Suluba, E., Shuwei, L., Xia, Q., & Mwanga, A. (2020). Congenital heart diseases: genetics, non-inherited risk factors, and signaling pathways. In *Egyptian Journal of Medical Human Genetics* (Vol. 21, Issue 1). Springer. https://doi.org/10.1186/s43042-020-0050-1