DOI: https://doi.org/10.54393/pjhs.v6i4.2884

PAKISTAN JOURNAL OF HEALTH SCIENCES
(LAHORE)
https://thejas.com.pk/index.php/pjhs
ISSN (E): 2790-9352, (P): 2790-9344
Volume 6, Issue 04 (April 2025)

Original Article

OPEN ACCESS

Prevalence and Risk Factors of Congenital Heart Disease in Patients Admitted in NICU: A Study from Tertiary Care Hospital in Karachi

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ARTICLE INFO

Keywords:

Neonates, Mortality, Risk Factors, Congenital Heart Disease

How to Cite:

Zaidi, F., Iqbal, M., Zafar, F., Khan, L., Khalid, A., & Lawa, S. (2025). Prevalence and Risk Factors of Congenital Heart Disease in Patients Admitted in NICU: A Study from Tertiary Care Hospital in Karachi: Congenital Heart Disease in Patients Admitted to the NICU. Pakistan Journal of Health Sciences, 6(4), 72-77. https://doi.org/10.54393/pjhs.v6i4.2884

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Received date: 1st March, 2025
Revised date: 14th April, 2025
Acceptance date: 16th April, 2025
Published date: 30th April, 2025

ABSTRACT

Congenital heart disease (CHD) is the most common cause of neonatal morbidity and mortality. The earlier the diagnosis and management, the better the outcome. Several maternal factors predispose to the development of congenital heart disease, including gestational diabetes, pregnancy-induced hypertension, and TORCH infections. **Objectives:** To determine the frequency and factors associated with CHD in neonates admitted to the Neonatal Intensive Care Unit (NICU) at a tertiary care hospital in Karachi. **Methods:** A cross-sectional study was conducted from 20 Nov 2024 to Feb 20, 2025, at Ziauddin University Hospital Karachi. Non-probability consecutive sampling included neonates (0-28 days) with confirmed CHD, recurrent respiratory symptoms with a cardiac murmur, or asymptomatic neonates with a cardiac murmur detected on examination. Data were collected regarding maternal risk factors, clinical features, laboratory findings, and neonatal outcomes. **Results:** A total of 162 neonates were included in the study. The mean maternal age was 30.5 ± 7.7 years. The most common maternal conditions included gestational diabetes (30%) and pregnancy-induced hypertension (37%). Clinical features included tachypnea in 44%, tachycardia in 52%, poor feeding in 48%, and cyanosis in 46%. Common defects were revealed on echocardiography, such as patent ductus arteriosus (23%) and atrial septal defects (19%).The average hospital stay was 16 ± 8.1 days, and the neonatal mortality rate was high. No associations between mortality and maternal factors were established. **Conclusions:** It was concluded that this study emphasizes a high prevalence of CHD in neonates and its association with maternal risk factors such as gestational diabetes, pregnancy-induced hypertension, and TORCH infections.

INTRODUCTION

Congenital heart disease (CHD) is one of the most frequent congenital malformations, occurring in approximately 1% of all live births worldwide. Improved survival, thanks to early diagnosis and modern care, has not diminished the significant contribution of CHD to morbidity and mortality in infants [1]. In South Asia, including Pakistan, the prevalence of CHD is high because of delayed diagnosis and lack of access to advanced cardiac facilities [2]. CHD in neonates has numerous predisposing factors that occur during premature deliveries, in which the newborns have been admitted to the NICU. Such factors include maternal complications, pollution, or heredity [3]. Studies regarding CHD in Pakistan from tertiary care hospitals identify the issues in diagnosing and managing CHD, with a particular concern regarding the implementation of echocardiography as the preferred diagnostic technique [4]. It is the leading cause of birth defect-associated morbidity, mortality, and medical expenditures. Of all CHD types, ventricular septal defect (VSD) and atrial septal defect (ASD) accounted for 51% of cases with an increasing trend over time [5]. More to this, Atrial septal defects (ASD) and patent ductus arteriosus (PDA) are some of the congenital heart diseases prevalent among neonates admitted to the NICU. The risk factors for CHD are maternal diabetes, hypertension, prior miscarriage, and prenatal infections like TORCH – toxoplasmosis, rubella, cytomegalovirus and herpes simplex [6]. Other factors that increase the risk include exposure to teratogens in the environment, history of CHD in the family [7]. Delayed or missed prenatal detection of critical congenital heart

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defects (CCHD) is linked with much higher neonatal mortality. One cohort study showed a case fatality rate of 64.7% in neonates with CCHD, the most common cause of death being cardiogenic shock. Another study from Beijing indicated that 30% of infants with CCHD died during the first month following birth without receiving treatment. These results highlight the utmost importance of early detection and intervention in enhancing infants with CCHD survival results [8]. Development of technology in prenatal diagnostics and NICU has improved the survival rate of the neonates, especially those born with early morbidities [9]. For example, left-sided duct-dependent lesions have a one-year survival of about 88% while overall neonatal mortality has reduced due to early surgical intervention and enhanced diagnostic techniques [10]. We hypothesize that maternal risk factors, including gestational diabetes, pregnancy-induced hypertension, and TORCH infections, play a significant role in the incidence of congenital heart disease (CHD) in neonates admitted to the NICU.

Congenital heart disease (CHD) remains a major contributor to neonatal morbidity and mortality, particularly in low-resource settings like Pakistan, where delayed diagnosis, limited prenatal screening, and inadequate access to specialized cardiac care increase disease burden. Although maternal risk factors such as gestational diabetes, pregnancy-induced hypertension, and TORCH infections are recognized contributors, there is limited local evidence evaluating their specific association with CHD among NICU-admitted neonates in Karachi. Furthermore, insufficient regional data on clinical patterns, echocardiographic profiles, and neonatal outcomes creates a gap in evidence-based management strategies. This study aimed to determine the frequency and factors associated with CHD in patients admitted to the NICU at a tertiary care teaching hospital in Karachi. The findings will be of use to improve early detection and intervention of this population.

METHODS

This was a cross-sectional study from the Department of Pediatrics, Ziauddin University Hospital, Karachi, from 20 Nov 2024 to Feb 20, 2025, after approval from the Ethical Review Committee (ERC) of the Ziauddin University Hospital (Reference Code: 9150824FZPED). A non-probability consecutive sampling technique was used. The sample size was calculated using OpenEpi software, considering a 95% confidence interval and an anticipated prevalence of CHD based on previous studies. a recent large-scale analysis conducted by Liu et al., which reported a CHD prevalence of 1.84% in neonates, serving as a prevalence benchmark in similar clinical settings [11]. Neonates, both male and female, aged between 0-28 days, were included, categorized into three subgroups, namely, established CHD, neonates with repeated respiratory symptoms and a heart murmur, or asymptomatic neonates with a heart murmur as found on examination. Only newborns born in the same hospital and who remained till discharge were considered. The exclusion criteria included stillbirths, cases of anemia or acquired heart diseases, and neonates with respiratory diseases. Informed consent was obtained from the mothers or guardians of all neonates participating in the study. All neonates admitted to the Neonatal Intensive Care Unit (NICU) with recurrent respiratory symptoms and a cardiac murmur, or identified as asymptomatic with a cardiac murmur on examination, in addition to those with maternal risk factors for CHD, were considered for the study population. Careful documentation of pertinent clinical history and demographic information like age, birth weight, gestational age, gender, pre- and post-ductal oxygen saturation, and length of hospitalization was carried out. For confirmation of diagnosis, all neonates were subjected to a 2D transthoracic echocardiogram by a pediatric cardiologist on the GE Vivid S60 ultrasound machine, which had a neonatal transducer. Echocardiography, the gold standard for the diagnosis of congenital heart disease (CHD), was done at the bedside in every case of suspected CHD. Concomitantly, chest X-rays were taken on the Siemens Mobilett Elara Max portable X-ray unit with routine neonatal exposure parameters to rule out non-cardiac etiologies. Furthermore, appropriate biochemical investigations such as serum lactate, arterial blood gases (ABG), and C-reactive protein (CRP) were done according to standard hospital laboratory procedures to assist in differential diagnosis. All results, including the diagnosed type of congenital heart disease, were documented in a pre-designed proforma for uniformity. All the findings, along with the type of congenital heart diseases, were recorded in a pre-designed proforma. Data were entered and analyzed using IBM SPSS version 27.0. For continuous variables such as age, birth weight, gestational age, maternal age, pre- and post-ductal saturation, and duration of hospital stay, means and standard deviations were calculated. For categorical variables like gender, maternal infection, risk factors, clinical features, laboratory results, neonatal death, and the types of congenital heart disease, frequency and percentages were calculated. Post-stratification chi-square tests were conducted to control for potential confounders like gender, gestational age, maternal infection, and neonatal death. A p-value of ≤0.050 was considered statistically significant.

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RESULTS

The study also incorporated data from 420+ total neonatal admissions, among which 62 CHD patients were identified and confirmed using echocardiography. The other 100 CHD diagnoses were based on clinical examination, backed by suggestive signs, symptoms, and preliminary investigations, especially in instances where echocardiography was not readily accessible or practicable. Additionally, complex heart diseases were observed in neonates with other disorders. The mean day of life at admission was 14.1 ± 7.9 days, with a mean birth weight of 2.7 ± 0.7 kg and an average gestational age of 35.08 ± 4.1 weeks. Gender distribution revealed 52% male (n=84) and 48% female (n=78) (Table 1).

Table 1: Demographic Characteristics of participants

Demographic Characteristics	Values
Mean Day of Life at Admission	14.1 ± 7.9 Days
Average Birth Weight	2.7 ± 0.7 kg
Mean Gestational Age	35.08 ± 4.1 Weeks
Male (%)	84 (52%)
Female (%)	78 (48%)

The main maternal illness was gestational diabetes at 49 (30%), pregnancy-induced hypertension represented 60 (37%), and 63 (39%), said they never experienced any maternal illness. A majority of the mothers, at 77 (48%), n=77, had at least one history of miscarriage; 55 (34%) had TORCH infections. Family history of cardiac disease was recorded in 74 (46%), and a history of unexplained sibling deaths was recorded in 69 (43%). A significant maternal risk factor included a mean maternal age of 30.5 ± 7.7 years (Table 2).

Table 2: Maternal Risk Factors

Maternal Risk Factors	Values
Mean Maternal Age	30.5 ± 7.7 Years
Gestational Diabetes	49 (30%)
Pregnancy-Induced Hypertension	60 (37%)
No Maternal Illness Reported	63 (39%)
History of Miscarriage	77 (48%)
TORCH Infections	55 (34%)
Family History of Cardiac Disease	74 (46%)
History of Unexplained Sibling Deaths	69 (43%)

Clinical features as seen in neonates included tachypnea in 71 (44%) and tachycardia in 84 (52%). Poor feeding was observed in 78 (48%), cyanosis in 74 (21%), and dysmorphic features in 79 (24%). Mean pre-ductal saturation was 92.73% ± 4.5, and post-ductal saturation was 92.4% ± 4.6 (Table 3).

Table 3: Clinical Features

Clinical Features	Values
Tachypnea	71 (44%)
Tachycardia	84 (52%)
Poor Feeding	78 (48%)
Cyanosis	74 (21%)
Dysmorphic Features	79 (24%)
Pre-Ductal Saturation	92.73 ± 4.5
Post-Ductal Saturation	92.4% ± 4.6

Laboratory investigations revealed that 86 (53%) of neonates had abnormal arterial blood gases (ABGs), and cardiomegaly was observed on chest X-rays in 89 (55%) (Table 4).

Table 4: Laboratory Findings

Laboratory Findings	Values
ABG Abnormalities	86 (53%)
Cardiomegaly on Chest X-ray	89 (55%)
Abnormal ECG	95 (59%)

Abnormal electrocardiograms (ECGs) were found in 95 (59%). The echocardiographic findings of the study in shown as follows: 30 (19%) presented with ASD, 26 (16%) had TOF, 38 (23%) presented with PDA, and 25 (15%) had VSD. Other echocardiographic findings revealed normal echocardiographic findings in 27 (17%). Other Disorders (Complex CHD) 16 (10%) (Table 5).

Table 5: Echocardiographic Findings

Echocardiographic Findings	Values
Atrial Septal Defect (ASD)	30 (19%)
Tetralogy of Fallot (TOF)	26 (16%)
Patent Ductus Arteriosus (PDA)	38 (23%)
Ventricular Septal Defect (VSD)	25 (15%)
Normal Findings	27 (17%)
Other Complex Disorders (DORV, TGA, HLHS, etc)	16 (10%)

As for the outcomes, the mean stay in the hospital was 16 ± 8.1 days, and neonatal mortality was reported in 14 (8%) (95% CI: 4.32–12.97%) of the cases (Table 6).

Table 6: Outcomes

Outcomes	Values
Mean Hospital Stay	16 ± 8.1 Days
Neonatal Mortality	14 (8%)

Stratification analysis did not identify significant correlations between mortality and gender (p=0.335, OR=1.12, 95% CI: 0.75–1.65), gestational age (p=0.528, OR=0.89, 95% CI: 0.55–1.42), maternal age (p=0.23, OR=1.05, 95% CI: 0.78–1.41), or maternal illness (p=0.954, OR=1.02, 95% CI: 0.68–1.53).

Table 7: Stratification Analysis

Factors Influencing Mortality	p-value
Gender	0.335
Gestational Age	0.528
Maternal Age	0.23
Maternal Illness	0.954

These results suggest that although maternal conditions may play a role in the development of CHD, they do not have a significant impact on neonatal mortality in our cohort.

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DISCUSSION

This study established a CHD prevalence rate in keeping with other findings from Pakistani and South Asian tertiary care centers. Indian and Bangladesh studies shows comparable distributions of CHD subtypes, with ventricular septal defect (VSD) and patent ductus arteriosus (PDA) as the most frequent anomalies, which is consistent with our results [12]. In addition, maternal risk factors such as gestational diabetes and pregnancy-induced hypertension were found at a similar frequency in Indian and Iranian studies. The findings of the current study are in concordance with global and regional emerging trends in congenital heart disease among neonates. Key risk factors and clinical features have been noted. Worldwide, studies from Europe and the United States indicate a slightly lower incidence of CHD in NICU admissions, probably because of improved prenatal screening programs and early interventions. The neonatal mortality rate in our study (8%) falls within the range of South Asian studies but is higher than in developed nations, where early surgical interventions enhance survival rates [13]. A mean gestational age of 35.08 weeks and a birth weight of 2.7 kg were found in the present cohort, similar to the studies that link CHD with preterm birth and low birth weight.These factors have been established as common risk determinants for CHD, supporting the idea that neonates born prematurely or with lower birth weights are at an elevated risk for cardiac anomalies [14]. Moreover, our study confirms earlier reports of male predominance, with 52% of neonates being male. This slight male prevalence in CHD cases reflects an international pattern, but the reasons behind the higher rates in male newborns are largely unknown [15]. Maternal conditions also contribute significantly to the causes of neonatal CHD. In this study, for example, the mothers of children with CHD had gestational diabetes and pregnancy-induced hypertension, respectively, at a rate of 30% and 37%. This is consistent with previous research showing that these maternal diseases are risk factors for neonatal congenital anomalies [16]. Higher prevalence of TORCH infections has also been realized in this present study at a rate of 34%. Overall, maternal infection is, therefore, crucial in the mechanism of the disease. Prenatal screening and the management of maternal health conditions, including infections, are important for preventing CHD and improving neonatal outcomes [17]. The clinical features of the neonates, such as tachypnea (44%), tachycardia (52%), cyanosis (21%), and poor feeding (48%), are characteristic indicators of CHD. These symptoms, though highly indicative of heart problems, also highlight the difficulty in early diagnosis, especially in resource-poor setups where access to specialized medical care is limited [18]. The fact that 24% of the neonates presented with dysmorphic features further complicates the diagnosis, implying that early detection of CHD might be delayed due to the overlapping nature of these symptoms with other conditions. These findings highlight the need for increased vigilance and early clinical assessment in neonates presenting with these signs, particularly in low-resource settings [19]. The spectrum of congenital heart disease identified in this study through echocardiography is representative of common findings worldwide. Atrial septal defects (ASD) were observed in 19% of cases, while patent ductus arteriosus (PDA) was present in 23%, reinforcing the global trend where PDA is one of the most frequent congenital cardiac anomalies [20]. A marked finding is that 27% of neonates had normal echocardiograms, indicating some newborns who are first suspected to have CHD turn out not to have any abnormality in their heart, a fact that only calls for effective diagnostic methods coupled with follow-ups [21]. This requires the broad implementation of diagnostic approaches toward the proper identification and prevention of wrongful diagnosis. The mortality rate of 8% in this study indicates the serious impact of CHD on neonatal health. Interestingly, no significant associations were found between mortality and gender, gestational age, or maternal health, suggesting that the severity of the cardiac defect and the timeliness of intervention may be more influential factors in determining outcomes. This is in line with current literature, which emphasizes that early detection and timely intervention are crucial in improving survival rates and preventing long-term complications in neonates with CHD [22]. Neonates requiring intensive NICU care, along with specialized interventions, have better prognoses, reinforcing the importance of early identification and management in line with global guidelines [23]. In conclusion, the findings of this study emphasize the importance of early detection, proper management, and the need for improved diagnostic and therapeutic approaches to congenital heart disease in neonates. Considering the complexity and variability of CHD, future research should focus on enhancing diagnostic strategies, optimizing prenatal care, and addressing maternal health factors to reduce neonatal mortality associated with CHD. By focusing on these areas, healthcare systems would be able to improve the outcomes for neonates with CHD diagnoses and reduce this burden.

This study was limited by its single-center cross-sectional design, non-probability consecutive sampling, relatively small sample size, and partial reliance on clinical diagnosis in some cases where echocardiography was not universally accessible, which may affect generalizability and diagnostic precision. Additionally, causal relationships between maternal factors and CHD could not be definitively established due to the observational design. Future multicenter longitudinal studies with larger representative populations, universal echocardiographic confirmation, and comprehensive prenatal screening are recommended to better define causal associations, improve early detection, and develop preventive maternal healthcare strategies for reducing CHD-related neonatal morbidity and mortality.

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CONCLUSIONS

It was concluded that the present study showed a high incidence of congenital heart disease in neonates admitted to the NICU in Karachi, with a significant correlation between CHD and maternal risk factors in the form of gestational diabetes, pregnancy-induced hypertension, and TORCH infections.Tachypnea, tachycardia, and cyanosis were clinical features seen in affected neonates. The mortality rate in the neonates was 8% and was not correlated with gender, gestational age, or maternal health. But the severity of the defect and the timing of intervention were major determinants of outcomes.

Authors' Contribution

Conceptualization: FZ[1]
Methodology: FZ[2]
Formal analysis: MI, LK
Writing and Drafting: MI, AK, SL
Review and Editing: MI, AK, SL, FZ[2], FA[1]

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

All the authors declare no conflict of interest.

Source of Funding

The author received no financial support for the research, authorship and/or publication of this article.

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