Birth prevalence and late diagnosis of critical congenital heart disease: A population-based study from a middle-income country

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ABSTRACT

Aims : **There are limited data regarding critical congenital heart disease (CCHD) from middle-income countries (MIC). This study aims to determine the birth prevalence, rate of late diagnosis, and influence of timing of diagnosis on the outcome of CCHD.**

Setting and Design : **Retrospective observational cohort study in the State of Johor, Malaysia.**

Subjects and Methods : **All infants born between January 2006 and December 2015 with a diagnosis of CCHD, defined as infants with duct-dependent lesions or cyanotic heart disease who may die without early intervention. The late diagnosis was defined as a diagnosis of CCHD after 3 days of age.**

Results : **Congenital heart disease was diagnosed in 3557 of 531,904 live-born infants and were critical in 668 (18.7%). Of 668, 347 (52%) had duct-dependent pulmonary circulation. The birth prevalence of CCHD was 1.26 (95% confidence interval: 1.16–1.35) per 1000 live births, with no significant increase over time. The median age of diagnosis was 4 days (Q1 1, Q3 26), with 61 (9.1%) detected prenatally, and 342 (51.2%) detected late. The highest rate of late diagnosis was observed in coarctation of the aorta with a rate of 74%. Trend analysis shows a statistically significant reduction of late diagnosis and a significant increase in prenatal detection. However, Cox regression analysis shows the timing of diagnosis does not affect the outcome of CCHD.**

Conclusions : **Due to limited resources in the MIC, the late diagnosis of CCHD is high but does not affect the outcome. Nevertheless, the timing of diagnosis has improved over time.**

Keywords : Birth prevalence, critical congenital heart disease, late diagnosis, middle-income country

INTRODUCTION

Congenital heart disease (CHD) is the most frequent malformation with a reported incidence of 6–10/1000 live births worldwide.[1,2] The GBD 2017 CHD collaborators' study estimated 12 million people living with CHD globally in 2017, and it is a significant contributor to infant mortality in lower- and middle-income countries (LMIC).[3]

One in four of CHD is critical and requires early intervention or surgery. Critical CHD (CCHD) may remain asymptomatic and present later in hemodynamically compromised conditions leading to significant morbidity

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and mortality. Therefore, early detection of CCHD is crucial to reduce morbidity or mortality.[4-7]

Over the last few decades, many initiatives have taken place to improve the detection of CCHD. Among them is a prenatal diagnosis with a fetal echocardiogram and screening of a newborn with a pulse oximeter (POX). POX is highly specific and moderately sensitive in detecting CCHD[8] and is a well-accepted practice in high-income countries (HIC).[9-11] However, the availability and utility of fetal echocardiogram and POX are limited in the LMIC.[12,13]

Previous studies on the delayed diagnosis of CCHD were compounded by many definitions. Among definitions used were diagnosis after birth hospital discharge, diagnosis after birth, or diagnosis after 3 days of life.[14] Despite the advances in medical services in developed countries, the reported prevalence rates of late diagnosis of CCHD is still high at 10%–30%.[15-18]

In LMIC, with limitations in trained professionals, infrastructure, and comprehensive tertiary cardiac services, we postulate the late diagnosis of CCHD to be high. However, to the best of our knowledge, there is no study in Malaysia or middle-income countries (MICs) addressing this issue. Therefore, the objectives of the study were to determine the birth prevalence, clinical presentation, prevalence of late diagnosis of CCHD, and its temporal trend over time. Another objective was to study the effect of late diagnosis on the outcome of CCHD.

SUBJECTS AND METHODS

Study population

This retrospective cohort study includes all infants with CCHD born alive in the State of Johor, Malaysia, from January 2006 to December 2015 with a follow-up from birth up to 12 years of age. Malaysia is located in Southeast Asia and is considered an upper-MIC. It has an estimated population of 30 million and consists of 13 states and three federal territories. The State of Johor is located on the West Coast of peninsula Malaysia, with an estimated population of 3.5 million and an average live birth of 50,000 per year. The pediatric cardiology services in the State of Johor were started in 2006, and managed by a single pediatric cardiologist. Government hospitals deliver health services in Johor. The majority of the infants were born in a government hospital and had a full clinical examination before hospital discharge. Most infants were reviewed at regular intervals at 1, 3, 4, 6, 12, and 18 months of life for immunization at government health clinics. Fetal echocardiography to detect CCHD among high-risk pregnancies were only well established from 2010 onward. However, termination of pregnancy for the fetal anomaly is not allowed in Malaysia. Meanwhile, POX screening for CCHD was not yet available during the study.

Data source

We retrieved the data from the Pediatric Cardiology Clinical Information System (PCCIS). PCCIS is a population-based clinical registry for congenital and acquired heart disease in children for the State of Johor.[19] Data retrieved were the age of diagnosis, clinical presentations, and outcome. The CHD diagnosis was made using two-dimensional (2D)-echocardiogram, and in cases where the 2D-echocardiography is inconclusive, cardiac magnetic resonance imaging, cardiac computed tomography scan, or cardiac angiogram data were used.

Case ascertainment and critical congenital heart disease classification

All suspected CCHD patients had a thorough cardiac assessment, including cross-sectional, Doppler, and color imaging echocardiography performed by a pediatric cardiologist. CCHD is defined as an infant with a duct-dependent lesion or cyanotic CHD who may die without early intervention regardless of the timing of intervention or death.[8,18] This is to prevent the underdiagnosis of CCHD.

CCHD was divided into four main groups, as described in previous studies.[19-21] Briefly, the first include those with duct-dependent pulmonary circulation (DDPC) for all lesions associated with pulmonary atresia (PA), severe pulmonary stenosis (PS), or tricuspid atresia. The second group, with duct-dependent systemic circulation (DDSC), includes hypoplastic left heart syndrome (HLHS), critical or severe coarctation of the aorta (CoA), interrupted aortic arch, and critical or severe aortic stenosis (AS). The third group, parallel circulation (PC), includes the D-transposition of great arteries (TGA), either simple or complex TGA without PA. Other CCHD but nonduct dependent lesions such as truncus arteriosus, and total anomalous pulmonary venous drainage (TAPVD) were grouped as a critical nonduct dependent lesion (CNDD).

The date of diagnosis is defined as the first time in which infants with CCHD underwent confirmatory echocardiography. The timing of diagnosis was then put into four main groups: within 72 h of life, within 4–7 days, within 8– 28 days, and >28 days of life. As described by Peterson *et al.*, late diagnosis is defined as a diagnosis of >3 days of life.[14]

Management of critical congenital heart disease

On the diagnosis of CCHD, all infants were stabilized according to their clinical states. Infusion of intravenous prostaglandin E1 was commenced for DDPC and DDSC, and where needed, balloon atrial septotomy for PC. Due to the limited congenital cardiac surgery services in Malaysia, all corrective or repaired CCHD in the

state of Johor were done in the major cardiac center in Kuala Lumpur. However, those with a lethal congenital malformation, severe medical condition, or complex single ventricle heart (HLHS and heterotaxia) were treated with comfort care and were excluded from the outcome analysis.

Exclusion criteria

All newly diagnosed CCHD in the State of Johor but were born in other states of Malaysia were excluded from this study.

Ethical approval

This study was approved by the Malaysian Research and Ethics Committee with the identification number of NMRR-16-734-30438(IIR).

Statistic analysis

We used Statistical Package for the Social Sciences Version 23 (IBM Corp., Armonk, NY) to analyze the data. We acquired the actual number of live-born infants in the State of Johor from the Johor Department of Health to calculate the birth prevalence of CCHD. Group comparisons were made using Pearson Chi-square or Fisher's exact test when any expected cell count was <5 for categorical data. We used Epical 2000 Version 1.02 (Joe Gilman & Mark Myatt, 1998, Brixton Books) to analyze the trend of late diagnosis over time. Univariable Cox-regression analysis was used to analyze the effect of late diagnosis on the outcome of CCHD. A value of $P < 0 \cdot 05$ represented a statistically significant result.

RESULTS

Over 10 years, a total of 531,904 infants were live births, with 3557 having CHD, and 668 (18.7%) were critical. Of 668, 10.5% were premature infants, 56% of males, 68% of Malay ethnicity, 84.4% had isolated CHD, 18.4% were infants of diabetic mothers, and only 1.2% had a family history of CHD. The birth prevalence of CCHD during the study period was 1.26/1000 live births (95% confidence interval [CI]: 1.16–1.35]. Table 1 shows the frequency and birth prevalence of specific CCHD. The majority of CCHD were DDPC (52%), followed by DDSC (23%).

Table 2 shows the timing of the diagnosis of various types of CCHD. The median age of timing of diagnosis was at 4 days (Q1 1, Q3 26). Of the 668 CCHD, 61 (9%) were detected prenatally. The overall prevalence of late diagnosis in this study was 51.2% (95% CI 47.3%–55.0%). The highest rate of late diagnosis was observed with CoA, TAPVD, and AS with a rate of 74%, 71%, and 71%, respectively.

Table 3 shows the clinical presentations in relation to the type of CCHD. The majority of CCHD presented with cyanosis with or without respiratory distress. However, 12% were asymptomatic, with only a cardiac murmur at the time of diagnosis.

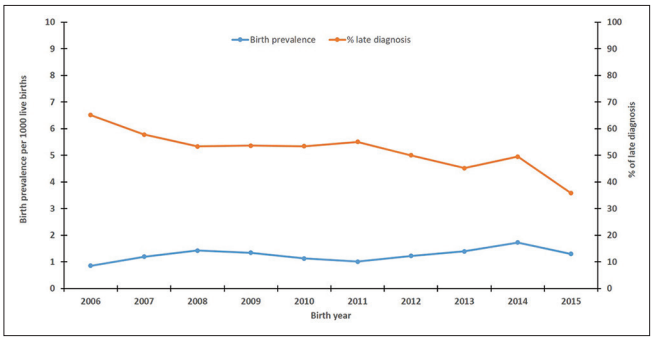

Figure 1: The trend over time of birth prevalence and rate of late diagnosis (diagnosis after 3 days of life) of critical congenital heart disease

Table 1: Birth prevalence of critical congenital heart disease

Type and diagnosis-specific lesion	Total (*n*)	Percentage of critical CHD	Birth prevalence* (95% CI)
Duct dependent pulmonary circulation	347	51.9	0.65 (0.58–0.72)
Complex CHD	97	14.5	0.18 (0.15–0.22)
Tetralogy of Fallot	63	9.4	0.12 (0.09–0.15)
Pulmonary atresia with ventricular septal defect	48	7.2	0.09 (0.06–0.12)
Pulmonary atresia with intact septum	44	6.6	0.08 (0.06–0.11)
Tricuspid atresia	43	6.4	0.08 (0.06–0.11)
Severe pulmonary stenosis	36	5.4	0.07 (0.05–0.09)
Ebstein anomaly	16	2.4	0.03 (0.02–0.04)
Duct dependent systemic circulation	152	22.8	0.29 (0.24–0.33)
Severe coarctation of aorta	53	7.9	0.10 (0.07–0.13)
Hypoplastic left heart syndrome	49	7.3	0.09 (0.07–0.12)
Interrupted aortic arch	17	2.5	0.03 (0.02–0.05)
Critical or severe aortic stenosis	7	1.0	0.01 (0.00–0.02)
Complex CHD	26	3.9	0.05 (0.03–0.07)
Parallel circulation	88	13.2	0.17 (0.13–0.20)
D-transposition of great arteries	88	13.2	0.17 (0.13–0.20)
Nonduct dependent	81	12.1	0.15 (0.12–0.18)
Total anomalous pulmonary venous drainage	35	5.2	0.07 (0.04–0.09)
Truncus arteriosus	26	3.9	0.05 (0.03–0.07)
Complex CHD	20	3.0	0.04 (0.02–0.05)
All	668	100.0	1.26 (1.16–1.35)

*Per 1000 live births. CI: Confidence interval, CHD: Congenital heart disease

Table 2: Timing of diagnosis and rate of late diagnosis of critical congenital heart disease

Type and diagnosis-specific lesion	Total (*n*)	Timing of diagnosis in days, median (Q1, Q3)	Prenatal diagnosis, *n* (%)	Late diagnosis*	
				n (%)	95% CI
Duct dependent pulmonary circulation	347	5 (1, 37)	39 (11.2)	164 (47.3)	41.9–52.7
Complex CHD	97	4 (0, 39)	14 (14.4)	50 (51.5)	41.2–61.7
Tetralogy of Fallot	63	8 (1, 72)	3 (4.8)	40 (63.5)	50.3–75.0
Pulmonary atresia with ventricular septal defect	48	2 (1, 11)	2 (4.2)	17 (35.4)	22.5–50.6
Pulmonary atresia with intact septum	43	2 (1, 7)	5 (11.6)	14 (32.6)	30.7–61.0
Tricuspid atresia	44	2 (1, 54)	7 (15.9)	20 (45.5)	19.5–48.7
Severe pulmonary stenosis	36	6 (1, 93)	1 (2.8)	20 (55.6)	38.3–71.7
Ebstein anomaly	16	0 (0, 2)	7 (43.8)	3 (18.8)	5.0–46.3
Duct dependent systemic circulation	152	12 (1, 19)	15 (9.9)	86 (56.6)	48.3–64.5
Severe coarctation of aorta	53	11 (3, 50)	1 (1.9)	39 (73.6)	59.4–84.3
Hypoplastic left heart syndrome	49	3 (0, 9)	9 (18.4)	21 (42.9)	29.1–57.7
Interrupted aortic arch	17	4 (0, 10)	1 (5.9)	9 (52.9)	28.5–76.1
Critical or severe aortic stenosis	7	8 (1, 32)	0 (0.0)	5 (71.4)	30.3–94.9
Complex CHD	26	2 (0, 14)	4 (15.4)	12 (46.2)	27.1–66.2
Parallel circulation	88	2 (1, 14)	4 (4.5)	37 (42.0)	31.7–53.0
D-transposition of great arteries	88	2 (1, 14)	4 (4.5)	37 (42.0)	31.7–53.0
Nonduct dependent	81	12 (2, 61)	3 (3.7)	25 (30.9)	56.5–77.6
Total anomalous pulmonary venous drainage	35	14 (3, 53)	0 (0.0)	25 (71.4)	53.5–84.7
Truncus arteriosus	26	9 (2, 25)	0 (0.0)	17 (65.4)	44.4–82.1
Complex CHD	20	8 (2, 93)	3 (15.0)	13 (65.0)	40.9–83.7
All	668	4 (1, 26)	61 (9.1)	342 (51.2)	47.3–55.0

*Diagnosed after 3 days of life. CI: Confidence interval, CHD: Congenital heart disease

Table 3: Clinical presentation at diagnosis of a specific type of critical congenital heart disease

Type and diagnosis of a specific lesion	Total (*n*)	Clinical presentation at diagnosis				
		Cyanosis without respiratory distress, *n* (%)	Cyanosis with respiratory distress, *n* (%)	Asymptomatic cardiac murmur, *n* (%)	Respiratory distress with no cyanosis, *n* (%)	Shock and collapse, *n* (%)
Duct-dependent pulmonary circulation	347	217 (62.5)	73 (21.0)	44 (12.7)	9 (2.6)	4 (1.2)
Complex CHD	97	61 (62.9)	26 (26.8)	7 (7.2)	3 (3.1)	0 (0.0)
Tetralogy of Fallot	63	40 (63.5)	14 (22.2)	9 (14.3)	0 (0.0)	0 (0.0)
Pulmonary atresia with ventricular septal defect	48	31 (64.6)	8 (16.7)	7 (14.6)	2 (4.2)	(0.0)
Pulmonary atresia with intact septum	43	34 (79.1)	8 (18.6)	0 (0.0)	0 (0.0)	1 (2.3)
Tricuspid atresia	44	29 (65.9)	7 (15.9)	5 (11.4)	1 (2.3)	2 (4.5)
Severe pulmonary stenosis	36	16 (44.4)	4 (11.1)	14 (38.9)	2 (5.6)	0 (0.0)
Ebstein anomaly	16	6 (37.5)	6 (37.5)	2 (12.5)	1 (6.3)	1 (6.3)
Duct-dependent systemic circulation	152	27 (17.8)	31 (20.4)	25 (16.4)	39 (25.7)	30 (19.7)
Severe coarctation of aorta	53	4 (7.5)	4 (7.5)	13 (24.5)	24 (45.3)	8 (15.1)
Hypoplastic left heart syndrome	49	15 (30.6)	16 (32.7)	7 (14.3)	3 (6.1)	8 (16.3)
Interrupted aortic arch	17	5 (29.4)	2 (11.8)	1 (5.9)	5 (29.4)	4 (23.5)
Critical or severe aortic stenosis	7	0 (0.0)	1 (14.3)	1 (14.3)	2 (28.6)	3 (42.9)
Complex CHD	26	3 (11.5)	8 (30.8)	3 (11.5)	5 (19.2)	7 (26.9)
Parallel circulation	88	43 (48.9)	35 (39.8)	2 (2.3)	3 (3.4)	5 (5.7)
D-transposition of great arteries	88	43 (48.9)	35 (39.8)	2 (2.3)	3 (3.4)	5 (5.7)
Nonduct dependent	81	15 (18.5)	35 (43.2)	8 (9.9)	19 (23.5)	4 (4.9)
Total anomalous pulmonary venous drainage	35	7 (20.0)	19 (54.3)	3 (8.6)	4 (11.4)	2 (5.7)
Truncus arteriosus	26	4 (15.4)	11 (42.3)	4 (15.4)	7 (26.9)	0 (0.0)
Complex CHD	20	4 (20.0)	5 (25.0)	1 (5.0)	8 (40.0)	2 (10.0)
All	668	302 (45.2)	174 (26.0)	79 (11.8)	70 (10.5)	43 (6.4)

Percentage of total critical CHD. CHD: Congenital heart disease

Figure 1 shows the birth prevalence and rate of late diagnosis of CCHD over time. Over the 10-year study period, there was no statistically significant increase in the birth prevalence of CCHD, but trend analysis shows a statistically significant reduction of late diagnosis from 65% in 2006 to 36% in 2015, $P = 0.002$.

Further analysis shows a significant reduction of late diagnosis in an infant with DDPC (from 60% in 2006 to 25% in 2015, $P = 0.005$) and DDSC (from 83% in 2006 to 48% in 2015, $P = 0.026$), and a statistically significant increase in prenatal detection (from 5.2% in 2006-2010 to 12.5% in 2011-2015, $P = 0.001$).

Of the 668, 166 (25%) were treated with comfort care, and 502 (75%) were actively managed. Unfortunately, of 502, 35% died. Of the 176 who died, 45% died before surgery (36 late and 43 early diagnoses), 22% within 30 days (21 late and 17 early diagnoses), 21% after 30 days of surgery (20 late and 17 early diagnoses), and

12% had missing data. There is no statistically significant difference in the mortality rate between late and early diagnosis (33% vs. 37%, $P = 0.365$). Cox regression analysis showed that late diagnosis has no statistically significant effect on the outcome of CCHD with a hazard ratio of 0.76 (95% CI; 0.56–1.02), $P = 0.074$.

DISCUSSION

Birth prevalence

To the best of our knowledge, this is the first population-based study from Malaysia and Asian countries looking at the birth prevalence and timing of the diagnosis of CCHD. The overall birth prevalence of CCHD in our study was 1.26/1000 live births, with no significant increase over time. This rate is within the reported studies at 1–2/1000 live births.[6,15] However, it is slightly low from studies in the United States of America at 1.7/1000 live births. The difference is due to the variation in the definition and rather strict echocardiography criteria for CCHD in our study. Most publications in the United States of America included tetralogy of Fallot (TOF) as CCHD.[5-7,13] However, we only included TOF if they have severe PS and require an urgent palliative shunt. In addition to that, we also excluded pulmonary atresia with ventricular septal defect with multiple collaterals and complex CHD without left or right ventricular outflow tract obstruction. This is because these lesions are not duct-dependent and do not require early intervention. These conditions may explain the slightly low birth prevalence of CCHD. Another reason for the low prevalence is due to the lack of autopsy in children who died at home or brought in dead to the hospital.

Timing of diagnosis

In this study, 51% or one in two CCHD had late detection, and one in four were detected after 1 month of age. This rate is high compared with the developed countries. In a recent review by Peterson *et al.*, the rate of late diagnosis among infants in the United States of America ranges from 4.3% to 31.3%.[14] Meanwhile, Eckersley *et al.* from New Zealand noted 20% of CCHD in their cohort were detected late,[15] and Wren *et al.* found that 30% of CCHD were undiagnosed at the time of discharge from hospital.[18] The high number of late diagnoses in this cohort is not surprising and can be due to many reasons. As in other MICs, the main reason was lack of awareness among primary caregivers, coupled with a lack of resources and expertise to detect CCHD.[13,22] In the developed countries, fetal echocardiography and POX are widely available, well-accepted practices and has led to an increase in the prevalence of prenatally detected CCHD.[23] This is in contrast to the LMIC, where prenatal diagnosis is limited, i.e., only 10% of CCHD were detected antenatally in this study. Meanwhile, POX screening for CHD in the newborn was not available during this study.

Similar to other studies, our results show a high rate of late diagnosis in CoA and TAPVD.[15,17] The late diagnosis of these two lesions could be due to the nature of the lesion and clinical presentation. In CoA, the severity of lesions may change over time and varies with the presentation. This study shows that one in four of the CoA can remain asymptomatic without any respiratory distress or cyanosis. Furthermore, almost 50% of CoA had respiratory distress without cyanosis, which could be easily confused with pneumonia or sepsis. Meanwhile, TAPVD has various degrees of obstruction, leading to cyanosis and respiratory distress mimicking meconium aspiration syndrome or pneumonia in newborns. Hence, these two lesions can be easily missed by the medical staff.[9,10] Therefore, a high index of suspicion and good clinical acumen is needed to improved diagnosis.

Despite the high rate of late diagnosis in this study, there was a gradual reduction in the trend of late diagnosis from 65% in 2006 to 35% in 2015. The reduction of late diagnosis is due to improvement in prenatal detection (from 5% in 2006–2010 to 12% in 2011–2015) and increase awareness, as well as improved clinical acumen among medical staff leading to early diagnosis. A gradual rather than dramatic reduction is noted due to the introduction of a small-scale, continuous training program of fetal and pediatric cardiology in the State of Johor. This led to an increase in the index of suspicion for CCHD and an increase in clinical acumen among clinicians caring for sick neonates. In addition to the training program, early postnatal diagnosis of CCHD was achieved due to readily available echocardiography services in all six district hospitals in the state toward the end of the study.

Clinical presentation

This study also highlights specific clinical signs for certain groups of CCHDs; cyanosis without any respiratory distress for DDPC and PC, shock and collapse within the 1st week of life for DDSC, and cyanosis with respiratory distress for nonduct dependent CCHD. Hence, this clinical information may help in making early diagnosis and management, i.e., the early institution of prostaglandin in an infant who presented with shock within the first week of life.

In addition, this study shows that 12% of infants with CCHD were asymptomatic, i.e., no cyanosis or having respiratory distress at the time of diagnosis. Lack of cyanosis could be due to persistent patent ductus arteriosus, maintaining the pulmonary and systemic circulations. Lack of cyanosis in this group of infants may lead to false-negative POX. Furthermore, neonatal clinical examination before discharge failed to detect a significant number of neonates with CCHD.[24,25] Therefore, in a center with in-house pediatric echocardiography service,

all asymptomatic newborns with a cardiac murmur should have a 2D-echocardiogram done before discharge postdelivery to exclude CCHD.

The results of this study represent the pre-POX era and shall serve as baseline data for the late diagnosis of CCHD. Despite all the problems associated with POX in LMIC,[12,13] we strongly believe POX should be introduced as a newborn screening program in Malaysia. As POX has good sensitivity with hypoxemic cardiac lesions (DDPC and PC), further reduction of late diagnosis in this group is feasible. Hence, the high prevalence of late diagnosis can be further reduced.

As in other LMICs, congenital cardiac services are still lacking in infrastructure and human resources. Currently, there are only 48 registered pediatric cardiologists in Malaysia, covering its 30 million population and an estimated annual birth of 500,000 per year. Most of the states in Malaysia are without a dedicated pediatric cardiologist. Hence, a general pediatrician, neonatologist, or paramedic needs to acquire the skill in 2D-echocardiogram in detecting critical lesions. As shown in our study, a good continuous training program for echocardiography in CHD, even though done on a small scale, is feasible in LMIC to reduce late diagnosis. Therefore, 2D-echocardiogram in neonates and children should not be limited to just pediatric cardiologists.[26,27]

Critical congenital heart disease outcome

This study highlights the high morbidity and mortality of CCHD in the LMIC. One in four was treated with comfort care, while one in three died, with most of them while waiting for surgery. In addition, unlike studies from HIC,[4,5,7,15] this study found that the timing of diagnosis has no significant effect on the outcome of CCHD. This is due to limitations in infrastructure, trained professionals in primary and secondary care, as well as congenital cardiac surgery services. Therefore, improvement in these areas, particularly in managing CCHD in small and syndromic infants[19] is needed in order to see changes in the outcome related to the timing of diagnosis.

Limitations of the study

We are aware of a few limitations in the study. First, the arbitrary definition of late diagnosis of CCHD. To date, there is no standardized definition of late diagnosis. Ideally, the definition needs to tailor to the individual lesions as each lesion may cause different impacts. Diagnoses of CCHD beyond 3 days of life were chosen due to the availability of data in the clinical registry and for comparison with other studies.[14-16]

The second limitation was a lack of more detailed variables and the presence of missing data. This is unavoidable as the data was derived from the clinical registry of a population across a 10-year period.

Finally, as there is a wide variation in healthcare deliveries in Malaysia, our results may or may not represent the whole nation. We postulate that the rate of late diagnosis may be higher. Hence, a need for a national study to determine the actual prevalence of late diagnosis and its effect on the outcome of CCHD in Malaysia.

CONCLUSION

The birth prevalence of CCHD in LMIC is similar to the HIC. However, the late diagnosis of CCHD is high, with one in two detected late and has no statistically significant effect on the outcome of CCHD in LMIC. Despite the limitation in resources in LMIC, the late diagnosis has gradually improved over time due to the introduction of small-scale continuous fetal and pediatric cardiology training programs.

Cyanosis with or without respiratory distress is a common clinical presentation for CCHD. However, one in five were not cyanosed, making early detection with POX and clinical diagnosis more challenging.

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Conflicts of interest

There are no conflicts of interest.

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