



# Spectrum of Heart Diseases in Children in a National Cardiac Referral Center Tanzania, Eastern Africa: A Six-Year Overview

ORIGINAL RESEARCH

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## ABSTRACT

**Background:** While communicable diseases have long been the primary focus of healthcare in Africa, the rising impact of paediatric and congenital heart disease (CHD) cannot be overlooked. This research aimed to estimate the frequency and pattern of heart diseases in children who underwent their first echocardiography at a national cardiac referral hospital in Tanzania.

**Methods:** A retrospective observational study was conducted on children aged 0 to 18 years referred for first-time cardiological evaluation from January 2017 to December 2022. Retrieval of social and echocardiogram data and descriptive analysis were performed.

**Results:** There were 6,058 children with complete reports. Of these, 52.8% (3,198) had heart disease, of whom 2,559 (80%) had CHD, while (340/639; 53.2%) with acquired heart disease (AHD) had rheumatic heart disease (RHD). Children with CHD had a median age 1.0 years (IQR: 0.3–3.5) and were predominantly 51.2% male. Children with RHD had a median age 9.7 years (IQR: 3.2–13.8) with equal gender distribution. Shunt lesions were common in 1,487 (58.1%), mainly VSD 19.3%, PDA 19.1%, ASD 15.1%, and atrioventricular septal defect (AVSD) 4.6%. Pulmonary valve stenosis was in 97 (3.8%). Around 35% (718) had cyanotic CHD, with TOF being most common (13.3%), followed by double outlet right ventricle (DORV) (3.6%). Compared to global average truncus arteriosus was higher in 69 (2.3%) children. In contrast, TGA and hypoplastic left heart syndrome (HLHS) were lower than the estimated global average seen in 2.3% and 0.5% of the cases, respectively. Atresia of the right-side valves was more common (174 vs. 24), and approximately 40% of the patients referred for first-time echocardiographic evaluation required hospitalization.

**Conclusion:** Congenital heart disease is the primary cause of heart disease in children presenting at a national referral hospital, surpassing RHD. With its distinct

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distribution pattern, acyanotic lesions are more frequent than cyanotic heart diseases. The observed late referral tendencies suggest improving the referral system, enhancing CHD awareness among healthcare professionals, and instituting nationwide screening programs.

## WHAT WAS KNOWN ABOUT THIS TOPIC?

1. Worldwide, congenital heart disease (CHD) is increasingly recognised as a childhood disease of public health importance.
2. There is a persistent burden of rheumatic heart disease (RHD) in developing countries.
3. Data are lacking in LMIC to inform policies and guide practice.
4. The distribution pattern of CHD may differ, driven by the healthcare landscape, genetic and environmental factors.
5. In developing countries, tetralogy of Fallot (TOF) is observed as the most common type of cyanotic heart disease. Ventricular septal defects (VSD), atrial septal defects (ASD), and patent ductus arteriosus (PDA) are the leading types of shunt lesions.

## WHAT IS NEW FROM THIS STUDY?

1. Congenital Heart disease is the primary cause of referral for cardiac evaluation in children in this developing country setting, surpassing rheumatic heart disease.
2. The distribution pattern of certain types of CHD differs significantly from global estimates.
  - a. There is a recorded high prevalence of double outlet right ventricle, tricuspid atresia and truncus arteriosus, in addition to tetralogy of Fallot.
  - b. There were lower frequencies of transposition of great arteries (TGA) and hypoplastic left heart syndrome (HLHS) and so were atresia of the left-sided valves in general.
3. The inefficiency and inadequacy of the cardiac program are concerning in providing comprehensive cardiac care in this setting.

## INTRODUCTION

Healthcare efforts in Africa have traditionally focused on combating communicable diseases such as malaria, diarrhoea, pneumonia, malnutrition, HIV, and tuberculosis (1). As the magnitude of these communicable diseases decreases, to the credit of concerted international efforts, congenital heart disease (CHD) emerges as an important health concern (2, 3). At a global level, CHD is recognised as the most common congenital anomaly (4). It is becoming the second leading cause of infant mortality in high-income countries (HIC) (6). Unfortunately, the exact prevalence of CHD in Africa is often unrecorded and underestimated (3, 4, 5). Nevertheless, in this region where rheumatic heart disease (RHD) is still endemic, there is a growing awareness of the significant impact of CHD (8–13).

Medical and surgical advancements enable infants born with CHD in North America and Europe to grow into healthy adults (7). Again, Africa faces a significant challenge, with the highest rate of unrepaired CHD cases; it is estimated that only 3% of children needing heart surgery in the continent receive it (9, 10, 31). The region's limited access to specialised care, insufficient treatment facilities, and inadequate attention to cardiac illnesses in children are the primary reasons for this disparity (14–21). These regional inequalities in diagnosis and treatment extend to other paediatric heart conditions, including RHD (22). While RHD has been nearly eliminated in HICs, it still affects millions of children and adults in other regions, particularly sub-Saharan Africa (SSA) (15, 22). In 2019, more than 33 million cases of RHD were reported globally, with over 90% residing in SSA (23).

Concerted efforts on multiple fronts are underway to alleviate the global burden and disparities in paediatric cardiac care and ensure better health outcomes for all individuals, regardless of their geographic location or socioeconomic status (18, 20, 21, 24). This includes increasing awareness of risk factors, strengthening healthcare infrastructure, providing resources for early detection and management, and promoting preventive measures (20, 21, 25). Following these efforts, cardiovascular centres treating paediatric heart disease increasingly emerge in

resource-limited settings, challenging the myth that such treatment is luxurious and excessively costly (16, 26). In India and China, successful outcomes are achieved at lower costs than in the global North (27, 28, 29). However, these centres suffer from location challenges (far from most patients' reach), leading to missed referrals, misdiagnoses, and delays in accessing specialised care due to transportation and financial limitations (16, 28). Gathering local data is pivotal for addressing gaps and achieving the global goal of providing care to all children with heart disease (3–5).

In Eastern Africa, Tanzania, the Jakaya Kikwete Cardiac Institute (JKCI) has been the sole cardiac facility, serving a population of 60 million since 2015. It is equipped with two state-of-the-art catheterization laboratories and three operating theatres, including one dedicated to paediatric care. The institute has a team of well-trained paediatric cardiac surgeons, cardiologists, intensivists, cardiovascular nurses, and support staff. To date, the centre has performed over 2,500 surgeries on children and sees approximately 40 children daily in an outpatient clinic (unpublished local database). However, extensive data on patient demographics, the spectrum of cardiac diseases, and social characteristics at the JKCI are yet to be published. The present study aims to fill this knowledge gap and provide insights into paediatric cardiac care at a national referral hospital in a low-resource setting.

## **METHODS**

### **STUDY DESIGN**

A single-centre retrospective study included patient data that had been documented in registration books/electronically between January 2017 and December 2022.

### **STUDY SETTING**

The Hospital Referral system in Tanzania operates at different levels. Level one is at the dispensary, level two at the health centre, level three at the district hospitals, level four at the regional hospital, level five at zonal hospitals, and the highest level at the national and specialised hospitals. The JKCI functions as a specialised national referral hospital. Patients will primarily be referred to JKCI from any of the 28 regional or six zonal hospitals. All other lower-level health facilities are advised against sending patients directly to JKCI.

### **STUDY PROCEDURE**

Cardiac consultation and echocardiography are performed by a paediatric cardiologist and well-trained and supervised paediatricians using two echocardiography machines: Siemens Logic 95 with 5S and 6S probes or a Vivid 9 Iq portable machine with 5H probes. The echocardiography included two-dimensional, colour, pulse wave, and continuous wave imaging. Routinely, a diagnosis is book recorded/entered into an online registry after a senior paediatric cardiologist's confirmation. ICD-10 disease classification is used to document diagnosis. The data registry also provides a daily plan of care. During the hospital visit, a senior cardiologist who runs an outpatient clinic must develop a care plan indicating the need for surgery, hospitalization, and prescribed medications. Patients requiring surgical/catheterization intervention are listed and discussed during multidisciplinary meetings on Friday.

### **DATA COLLECTION**

The JKCI transitioned to an online database for data recording in 2019. Data for the year 2015 were unavailable, and due to inaccuracies and incomplete entries in the registration books, data from 2016 and some from 2017 were excluded from the study. For 2017 and 2018, data were manually extracted from the registration book. The patient data included age, sex, type and severity of heart disease, and presence of extracardiac malformations, such as trisomy 21. Additionally, a conclusion regarding the need for an intervention, such as surgery, was drawn at the presentation time. From 2019 to 2022, data were retrieved from the online registry at JKCI by selecting new cases. The leading diagnosis was reported if more than one cardiac lesion was present. If additional data, including confirmation of age, was needed, patients were reached via telephone calls.

The study included all patients aged between 0 and 18 who presented as new cases to the JKCI between 2017 and 2022, and were diagnosed with a cardiac condition upon echocardiography. Patients were excluded from the final analysis if information regarding age, visit type, and diagnosis was incomplete.

DATA ANALYSIS

The data were inspected for duplication, manually checked for inconsistency, inputted in SPSS, and analyzed by simple descriptive statistics. Quality control was ensured through the database’s introspection of electronic medical records and cross-checking with database reports.

RESULTS

Between January 2017 and December 2022, over six thousand (6,934) children were subjected to an echocardiogram for the first time at JKCI, of which 6,058 had a complete report and analyzed. More than half of the children, 52.8% (3,198), were diagnosed with heart disease, while the rest had normal echocardiograms (as shown in Figure 1).

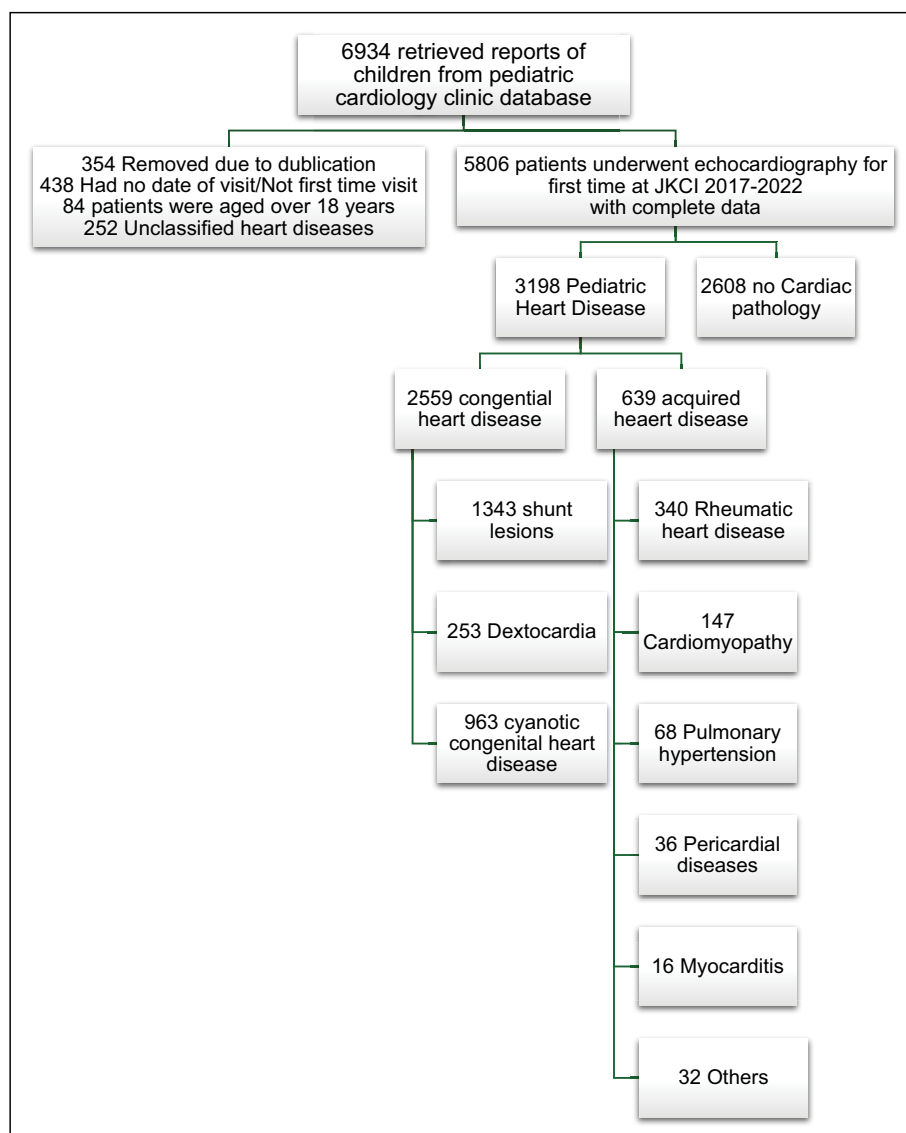


Figure 1 Flow chart of patients undergoing first Echocardiography at JKCI between 2017 to 2022.

Table 1 presents the demographic features of children with heart disease. The most common diagnosis was CHD, accounting for 80% (2,559/3,198). The median age of patients in this group was 1.0 years (IQR: 0.33–3.5), and 51.2% were male, with a median body weight of 7.0 kg (IQR: 5.0–12.0). Only 639 children were diagnosed with acquired heart disease (AHD), accounting for 19.7%; this group had a median age of 9.7 years (IQR: 3.2–13.8) and a weight of 21.0 kg (IQR: 11.0–32.6).

<b>VARIABLE</b>	<b>CONGENITAL HEART DISEASE (n = 2559)</b>	<b>ACQUIRED HEART DISEASE (n = 639)</b>	<b>TOTAL</b>
<b>Age in Yrs (Median; IQR)</b>	1.0 (0.33–3.5)	9.7 (3.2–13.8)	1.4 (0.4–5.8)
<b>Sex N(%)</b>			
<b>Female</b>	1250 (48.8%)	320 (50.1%)	1570 (49.1%)
<b>Male</b>	1309 (51.2%)	319 (49.9%)	1628 (50.9%)
<b>Body Weight in kg (Median; IQR), n = 2,403 CHD; n = 580 AHD</b>	7.0 (5.0–12.0)	21.0 (11.0–32.6)	8.0 (5.0–16.0)
<b>Height in cm (Median; IQR), n = 1,544 CHD; n = 352 AHD</b>	67 (57.0–89.0)	123.0 (86.3–144.0)	70.0 (59.0–103.0)

**Table 1** Demographic Characteristics of Children with Heart Disease.

CHD = congenital heart disease; AHD = acquired heart disease.

## CONGENITAL HEART DISEASE

Out of the 2,559 children diagnosed with CHD, the majority had acyanotic CHD (65%), while 893 (35%) of children presented with cyanotic CHD. Shunt lesions were observed in 1,487 (58.1%) children, primarily ventricular septal defect (VSD) at 19.3%, patent ductus arteriosus (PDA) at 19.1%, atrial septal defect (ASD) at 15.1%, and atrioventricular septal defect (AVSD) at 4.6%. Pulmonary valve stenosis was seen in 97 (3.8%) of children. For cyanotic heart disease, tetralogy of Fallot (TOF) was the most common at 13.3%, followed by double outlet right ventricle (DORV) at 3.6%. Truncus arteriosus was observed in 69 (2.3%) children, as was transposition of the great arteries (TGA) in 2.3% of the cases. Among those with congenital atresia of the cardiac valve, 87.8% were atresia of right-sided valves (pulmonary and tricuspid valves) at 6.8% of the total, compared to 0.9% for atresia of the left-sided valves (aorta and mitral valve). Additionally, congenital malformations of cardiac chambers (double inlet left/right ventricle) were observed in 233 (9.1%) of the total. Males made up the majority in all subgroups, averaging 51.1%, except for PDA, ASD, and AVSD, where females formed the majority at 59%, 54%, and 53%, respectively (see [Table 2](#)).

## ACQUIRED HEART DISEASE

Among children with AHD, the majority (53.2%; 340/639) had rheumatic heart disease (RHD), followed by dilated cardiomyopathy 23.0% and pulmonary hypertension, 10.6%. The rate of pericardial diseases was 5.6%, and that of myocarditis was 2.5% ([Table 3](#)).

The median age for the diagnosis of rheumatic heart disease was 11.0 years (IQR: 8.2–14.5), with females accounting for 48.2% of cases. The most common lesion types of RHD were mitral valve insufficiency and aortic valve insufficiency, both accounting for 26.8% of cases. Multiple valve disease was present in 21.8% of cases. Conversely, just 1.7% and 1.5% of cases, respectively, had mitral and aortic stenosis. The combination of mitral insufficiency and stenosis was present in only 2% of cases ([Table 4](#)).

## PLAN OF CARE

Out of the 2559 children diagnosed with CHD, 38% (990) required urgent attention during their first encounter in the cardiac facility. Of these children, 25% (249) required admission on the first day of echocardiography. The reasons for admission included medical stabilization (62%), surgery (29%), and catheterization procedures (8%). In addition, 69.1% (685/990) of these children needed further investigations but did not require admission. Children receiving medication as outpatients during their first visit were 5.7% (56).

Nearly 60% (1,524) of the children diagnosed with CHD had significant lesions that required intervention but were stable at their first visit and scheduled for follow-up. Only 1.8% (45) of the children with insignificant lesions were discharged from the clinic.

For those with RHD, nearly 60% had an established valvar disease, presenting with moderate/severe valvular damage, and needed surgical intervention on the first echocardiogram. However, they were in stable condition and received anti-failure treatment and Benzylpenicillin prophylaxis while waiting for planned surgery. Only 2% with severe RHD were too ill and needed

urgent surgery, while 13.8% (88) were admitted on the first visit for medical stabilization and/or treatment for intercurrent illness while waiting for planned surgery (see Table 5).

LESION TYPES	GENDER DISTRIBUTION				AGE AT DIAGNOSIS		YEAR OF DIAGNOSIS					
	MALE n 1,309	FEMALE n 1,242	TOTAL n 2,551	%	MEDIAN AGE	RANGE	2017	2018	2019	2020	2021	2022
Ventricular septal defect	279	213	492	19.2	1.0	16.5	112	54	83	58	101	84
Patent ductus arteriosus	200	286	486	19.0	0.9	17.3	67	45	70	69	135	100
Atrial septal defect	175	210	385	15.1	0.8	17.8	47	29	45	69	101	94
Tetralogy of Fallot	201	138	339	13.3	2.3	16.5	63	27	42	48	86	73
Dextrocardia	135	112	247	9.7	0.8	15.4	5	0	44	77	69	52
Atrio ventricular septal defect	56	63	119	4.7	0.6	17.1	29	15	15	4	26	30
Pulmonary valve stenosis	59	38	97	3.8	1.0	16.5	13	13	15	17	25	14
Transposition of great arteries	33	27	60	2.3	0.3	13.7	6	7	7	5	19	16
Double outlet right ventricle	49	44	93	3.6	1.0	17.7	11	7	16	13	23	23
Persistent truncus arteriosus	35	34	69	2.7	0.8	14.0	10	14	13	6	11	15
Pulmonary valve atresia	8	7	15	0.6	0.2	13.6	2	1	3	2	3	4
Hypoplastic left heart syndrome	6	7	13	0.1	1.4	6.7	0	0	0	3	7	4
Tricuspid atresia (or stenosis)	30	30	60	2.3	0.8	12.9	11	6	14	10	12	7
Others	43	33	76	2.9			5	5	11	12	18	23
<b>Total</b>							<b>381</b>	<b>223</b>	<b>378</b>	<b>393</b>	<b>636</b>	<b>539</b>

**Table 2** Distribution of Various Congenital Heart Diseases by Gender and Year.

DISTRIBUTION OF ACQUIRED HEART DISEASES N 639		
TYPES	FREQUENCY	PERCENTAGE
Rheumatic heart disease	340	53.2
Dilated cardiomyopathy	147	23.0
Myocarditis	16	2.5
Pericardial diseases	36	5.6
Pulmonary hypertension	68	10.6
Others	32	5.0

**Table 3** Distribution of Acquired Heart Disease.

TYPE	FREQUENCY	PERCENTAGE
Mitral stenosis	6	1.7
Aortic stenosis	5	1.5
Combined mitral disease	69	20.3
Aortic insufficiency	91	26.8
Multiple valve disease	74	21.8
Mitral insufficiency	91	26.8
Tricuspid insufficiency	4	1.2

**Table 4** Distribution of Rheumatic Heart Disease by Valvular Type N 340.

PLAN	PLAN FOR CHILDREN WITH CONGENITAL HEART DISEASE		PLAN FOR CHILDREN WITH ACQUIRED HEART DISEASE	
	FREQUENCY	PERCENT	FREQUENCY	PERCENTAGE
Established diagnosis, need treatment	1,524	59.6	375	58.7
Admitted for catheterization	21	0.8	0	0.0
Admitted for surgery	72	2.8	2	0.3
Admitted for medical treatment	156	6.1	88	13.8
Discharge from clinic	45	1.8	25	3.9
Further investigations	685	26.8	125	19.6
Medications	56	2.2	24	3.8

**Table 5** Plan of Care of Children with Heart Disease after First Echocardiography.

## DISCUSSION

### OVERALL RESULTS

We conducted a retrospective review of children suspected of having heart disease who presented for the first time for echocardiography at the Jakaya Kikwete Cardiac Institute in Tanzania. This facility is the only one at the moment in the area offering comprehensive cardiac care to children and adults. Our research findings revealed a significant proportion, 80%, of CHD. In contrast, only 10.6% of patients were found to have RHD despite it being the leading cause of AHD. Our study's CHD proportion is slightly higher than that of a comparable study conducted in Tanzania by Zuechner et al., which reported a proportion of 75%, but it is not surprising (32). Evidence from various reports in Africa indicates that CHD is becoming a more prevalent cause of childhood heart disease, surpassing RHD, driven by improved awareness, improved diagnostic tools, and enhanced socioeconomic conditions in the region (33–41).

### CONGENITAL HEART DISEASE

Expectedly, most, 65%, of the children with CHD in our cohort had acyanotic heart diseases, with VSD being the most common subtype, at a rate of 19%. Noteworthy, the frequency of VSD in African studies is lower (16–29%) than the estimated global average of 35% (5, 35). In Sudan, the VSD rate was 16.6% in a cohort of 596 patients; in Nigeria, it was 25%; in South Africa, 20%; in Botswana, 29%; and in Uganda, 27.2% out of 3526 patients (33–37). Similarly, a comparable study conducted in Tanzania from 2009 to 2016 indicated that the frequency of VSD was 26.1%, and a recent meta-analysis showed that the proportion of VSD in CHD in East Africa is 29.9% (32, 42). This difference in frequency distribution between regions is because CHD is diagnosed early in the North. Thus, most shunt lesions are detected, whereas, in the global South, limited financial resources and healthcare-seeking behavior may result in only children with symptoms seeking medical attention (10, 13, 14). As a result, many shunts may naturally close when they see a doctor or die before a diagnosis is made (15–18).

A significant difference in the distribution pattern was also observed in atrioventricular septal defect (AVSD), the most severe form of shunt lesions. In our study, the frequency of AVSD was 5%, similar to findings from other African studies. In the PROTEA registry in South Africa, AVSD was recorded at 7%, whereas in Sudan, it was 9%, Nigeria, 6%, and Uganda, 8% (33–35, 37). Inarguably, our study's distribution pattern of shunt lesions could indicate a lack of access to early detection, lack of prenatal screening, infrequencies of pregnancy termination, and selective detection of symptomatic lesions. However, further investigation is required to explore whether genetic and environmental factors contribute to this trend. Nevertheless, our findings confirm that most CHDs are relatively simple and amenable to surgical intervention (3–5, 43, 44).

Nearly a third of our patients with CHD presented with cyanotic heart disease. Moreover, the frequency of certain types of cyanotic heart diseases appeared higher in our cohort than in the global estimates. Specifically, we observed a greater occurrence of tetralogy of Fallot (13%), double outlet right ventricle (4%) and truncus arteriosus (2%), significantly higher than the

global averages of 5%, 1.3% and 1%, respectively (5). On the other hand, we found a lower prevalence of transposition of the great arteries (TGA) (2% vs. 5%) and hypoplastic left heart syndrome (HLHS) (0.5% vs. 2.5%). Of interest, we observed a high frequency of tricuspid atresia (3%), three times the global estimate and higher than reported in South Africa (1%) and Uganda (1.8%) (35, 37).

These differences in the distribution pattern of cyanotic heart diseases in our group may be due to differences in detection abilities. Since there is no systematic screening for CHD in the region, we assume that the observed pattern is mainly due to survival. The most severe cases may not have been detected at birth and could have resulted in death before detection. DORV, AVSD, and TOF are highly symptomatic, and tricuspid atresia has a balanced circulation nature, which allows for detection and, thus, the observed trends. Meanwhile, HLHS and TGA are lethal and, therefore, escape detection. It is important to note that the cyanotic CHD cases identified in our cohort are variations of the typical lesions that can lead to survival, while the more severe cases that result in death were not identified. This underscores the fact that serious forms of congenital heart disease (CHD), especially CCHD, are often overlooked or don't make it to specialised medical centres in developing countries due to limited screening of newborns and prenatal detection practices in these areas (12-18). However, we must recognise the differences in environmental exposure and genetic variability between the two hemispheres. Environmental factors, such as calcium deficiency and particulate matter, are believed to play a role in the incidence of some CHD. Targeted research and interventions are needed to better understand and control these risk factors (45-49).

Lastly, we observed a high number of patients, 247, presenting with dextrocardia in the CHD group, accounting for 10% of the total cases. This is ten times higher than the global average and the 0.4% recorded in the Eastern Africa series (37). Dextrocardia is a rare disorder of cardiac laterality with an unknown cause. It is thought to have a genetic influence based on its association with other genetic syndromes, such as Kartegener syndrome, and familial clusters. In population studies, its incidence is estimated to be 1 in 12,000 pregnancies (50, 51). Given the high rate of occurrence in our study, further investigation, including genetic determination, is necessary.

In terms of demographic characteristics, our CHD cohort had ages ranging from 0.35 to 3.5 years, older than those of the global North, whose children are mostly diagnosed in utero or soon after birth (3-5). These findings were not unexpected and attributed to the lack of a coordinated screening program in our setting. With respect to gender distribution, it is well known that males are more susceptible to complex congenital heart disease, while females are more likely to have shunt lesions (52). Therefore, the predominance of males in our cohort, given that the majority had shunt lesions, was surprising. However, it is important to note that gender distribution has shown different patterns in different groups, likely due to the dominance of specific lesions (52, 53).

## **BURDEN OF RHD AND OTHER ACQUIRED HEART DISEASES**

As expected, RHD was the most common AHD in our cohort study, accounting for 53.2% of the cases. This was followed by cardiomyopathies and pulmonary hypertension.

Globally, RHD is the primary cause of AHD in children and young adults, with a current estimated prevalence rate of 26.1% (23). However, a recent meta-analysis in East Africa suggests a decreasing trend of RHD in the region, with a reported rate of 14.6%, which is lower than the global estimate (55). This positive trend has been attributed to improvements in health services, better living conditions, and empowered communities (22, 23, 30, 54). Despite this, RHD remains common in many LMIC countries, particularly rural areas (23). Our RHD's proportion rate of 10.6% should be interpreted cautiously, as we lack a national RHD control program. Furthermore, as it is a disease of poverty, and with only one cardiac centre in the area, it is possible that many children with RHD cannot afford to travel for care (56). Thus, concerted efforts are required to identify high-risk areas and strengthen surveillance measures in Tanzania.

Unsurprisingly, dilated cardiomyopathy was the second most common cause of AHD in our cohort. Other studies, too, have recorded dilated cardiomyopathy as the second most common AHD in children (57-59). It is the most common cause of transplant need in the global North,



but its true burden in the global South is still lacking (60). However, having been associated with malnutrition and infectious disease, the burden is suspected to be substantial (22).

Our third most prevalent AHD, pulmonary hypertension, is increasingly recognised as an important cause of childhood mortality and morbidity; in children, it stems from the highest number of unrepaired CHD and RHD (61, 62). Since our cohort records a high rate of pulmonary hypertension, close follow-up is essential.

## PLAN OF CARE

Finally, our research revealed a concerning issue in the referral process for children with heart conditions. Nearly 60% of the referred children had no cardiac diagnosis, indicating an inaccurate referral. Among those with a cardiac diagnosis, 40% had to be hospitalised immediately upon arrival, suggesting delayed referral. The issue of inefficient referrals for children with heart conditions affects both high- and low-income countries (63–65). The root causes of this problem include a flawed referral system, a lack of trust in lower health facilities, and challenges that primary healthcare workers (PHWs) face in determining which patients to refer (66–68). In LMICs, families face additional referral delays due to limited accessibility to referral facilities, lack of transportation, and financial limitations (56).

Late diagnosis not only puts children at risk of additional health complications but also leads to poor surgical outcomes (28). In emerging cardiac programs like JKCI, inefficient referrals force the team to operate urgently and uncoordinatedly, jeopardizing output. To address these issues, PHWs require comprehensive training, standardised screening tools, and access to telemedicine services (15, 24, 27). Collaborating with specialised cardiac centres and establishing clear referral pathways can ensure timely diagnosis and treatment (20, 21). Subsequently, implementing quality assurance programs to monitor and evaluate the performance of PHWs will help improve their diagnostic skills (19, 73). Where feasible, exploring intelligent auscultation and using clinical scores can improve referrals and prevent overcrowding; indeed, implementing intelligent auscultation in resource-limited settings has been an area of active research in recent years (68–72).

## LIMITATIONS AND FUTURE RESEARCH RECOMMENDATIONS

This study has certain limitations. First, it being a hospital-based study introduces selection bias, leaving out children with subclinical symptoms or no access. Moreover, referral decisions were made by the referring doctors, potentially leading to a focus on patients with more severe symptoms and potentially overlooking asymptomatic patients. For these reasons, patients may not fully represent the actual situation in the broader community. However, it is worth noting that this particular centre serves as the sole referral centre for children with heart disease in the country. This study, therefore, provides insight into the burden and distribution of childhood heart disease in Tanzania.

Secondly, the retrospective nature of the study was limited by missing data. Therefore, we propose a prospective study and registry to better understand the nature of heart diseases affecting children in the country. Such initiatives would aid in identifying modifiable risk factors for prevention and shed light on ways to improve care delivery.

Despite these limitations, this study has provided valuable insights into the country's healthcare system challenges for children with heart disease.

## SUMMARY

Heart disease poses a significant challenge for children in Tanzania. Despite the government's efforts to make services available and provide super-specialised training in cardiovascular-related disciplines for doctors, nurses, and allied health care at the national level, several challenges must be overcome. One significant challenge is the inefficiency of referrals, which may compromise outcomes, overburden healthcare resources, and create inefficiency in cardiac care provision. An improved referral system for childhood heart disease must be established to address this challenge. One solution is training PHCW providers and implementing clinical aid decision-making tools at primary health facilities to ensure appropriate and timely referrals.

Additionally, policies should be enacted to include auscultation for every child attending well-baby clinics and while managing sick children at all levels in the country. Increasing the number of facilities available to manage childhood heart disease is also crucial.

In terms of heart disease distribution in the country, CHD is more prevalent than RHD at presentation. While this may indicate the disappearance of RHD, a lack of an RHD control program may suggest a lack of access; an RHD control program, therefore, is desirable. On the other hand, the distinct distribution patterns in CHD subtypes show the need for a comprehensive CHD registry to better understand the nature of CHD and its associated factors in this setting. Establishing a CHD screening program at birth for early detection is also necessary, and the rate of observed dilated cardiomyopathy and pulmonary hypertension requires close attention. Thus, implementing these measures will be essential in providing better care and improving outcomes for children with heart disease in Tanzania.

## CONCLUSIONS

Congenital heart disease (CHD) is the primary cause of heart disease in children presenting at the JKCI, surpassing rheumatic heart disease (RHD). Shunt lesions are more common, but the distribution of the CHD subtype differs significantly from global estimates. Notably, the rate of late and inappropriate referrals to JKCI poses a significant challenge and may jeopardise patient outcomes. To address this, it is crucial for the health system to improve referrals, enhance awareness among healthcare professionals, and institutionalise screening programs.

## ABBREVIATIONS

AHD – acquired heart disease

CHD – congenital heart disease

RHD – rheumatic heart disease

JKCI – Jakaya Kikwete Cardiac Institute

CCHD – critical congenital heart disease

PHCW – primary health care workers

HIC – high-income countries

LMIC – low- and middle-income countries

## DATA ACCESSIBILITY STATEMENT

The authors will make the raw data supporting this article's conclusions available without undue reservation upon request to the corresponding author.

## ETHICS AND CONSENT

The study was approved by the Ethics Committee of the JKCI (#AB.123/307/01H/68) and followed the ethical guidelines stated in the 1975 Declaration of Helsinki. As this was a retrospective study, the IRB granted a waiver for consent.

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## COMPETING INTERESTS

The authors have no competing interests to declare.

NM is a PhD candidate who came up with the research topic, contributed to the study design and data collection, and provided the first draft of the manuscript. JK contributed to the study design, conducted the data collection and analysis, and contributed the first draft of the manuscript. ZK, NL, SM, DN, SK, GS, and VM provided fundamental insights into children's CHD and provided critical feedback on the results. MS, PC, DG, PK, and MJ provided critical feedback on the manuscript drafts and mentorship for the data analysis.

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## REFERENCES

1. **Chilot D, Belay DG, Shitu K**, et al. Prevalence and associated factors of common childhood illnesses in sub-Saharan Africa from 2010 to 2020: a cross-sectional study. *BMJ Open*. 2022; 12: e065257. DOI: <https://doi.org/10.1136/bmjopen-2022-065257>
2. **Rossano JW**. Congenital heart disease: a global public health concern. *The Lancet Child & Adolescent Health*. 1 Mar 2020; 4(3): 168–169. DOI: [https://doi.org/10.1016/S2352-4642\(19\)30429-8](https://doi.org/10.1016/S2352-4642(19)30429-8)
3. **van der Linde D**, et al. Birth prevalence of congenital heart disease worldwide: a systematic review and meta-analysis. *Journal of the American College of Cardiology*. 2011; 58(21): 2241–2247. DOI: <https://doi.org/10.1016/j.jacc.2011.08.025>
4. **Zimmerman MS**, et al. Global, regional, and national burden of congenital heart disease, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet Child & Adolescent Health*. 2020; 4(3): 185–200. DOI: [https://doi.org/10.1016/S2352-4642\(19\)30402-X](https://doi.org/10.1016/S2352-4642(19)30402-X)
5. **Liu Y, Chen S, Zühlke L, Black GC, Choy MK, Li N, Keavney BD**. Global birth prevalence of congenital heart defects 1970–2017: updated systematic review and meta-analysis of 260 studies. *International Journal of Epidemiology*. 1 Apr 2019; 48(2): 455–463. DOI: <https://doi.org/10.1093/ije/dyz009>

6. **Wu W, He J, Shao X.** Incidence and mortality trend of congenital heart disease at the global, regional, and national level, 1990–2017. *Medicine (Baltimore)*. 2020; 99(23): e20593. DOI: <https://doi.org/10.1097/MD.00000000000020593>
7. **Kiraly L.** Current outcomes and future trends in paediatric and congenital cardiac surgery: a narrative review. *Pediatric Medicine*. 2022; 5. DOI: <https://doi.org/10.21037/pm-21-47>
8. **Zühlke L, Mirabel M, Marijon E.** Congenital heart disease and rheumatic heart disease in Africa: recent advances and current priorities. *Heart*. 2013; 99: 1554–1561. DOI: <https://doi.org/10.1136/heartjnl-2013-303896>
9. **Zimmerman M, Sable C.** Congenital heart disease in low-and-middle-income countries: focus on sub-Saharan Africa. *American Journal of Medical Genetics, Part C: Seminars in Medical Genetics*. March 2020; 184(1): 36–46. DOI: <https://doi.org/10.1002/ajmg.c.31769>
10. **Liu Y, Chen S, Zühlke L, Babu-Narayan SV, Black GC, Choy MK, Li N, Keavney BD.** Global prevalence of congenital heart disease in school-age children: a meta-analysis and systematic review. *BMC Cardiovascular Disorders*. Dec 2020; 20: 1–10. DOI: <https://doi.org/10.1186/s12872-020-01781-x>
11. **Malherbe HL, Aldous C, Woods D, Christianson A.** The contribution of congenital disorders to child mortality in South Africa. *South African Health Review*. 2016; 2016(1): 137–152.
12. **Tantchou Tchoumi JC,** et al. Occurrence and pattern of congenital heart diseases in a rural area of sub-Saharan Africa: cardiovascular topics. *Cardiovascular Journal of Africa*. 2011; 22(2): 63–66. DOI: <https://doi.org/10.5830/CVJA-2010-046>
13. **Hewitson J, Zilla P.** Children’s heart disease in sub-Saharan Africa: challenging the burden of disease. *SA Heart Journal*. 2010; 7(1): 18–29. DOI: <https://doi.org/10.24170/7-1-1964>
14. **Yuyun MF, Sliwa K, Kengne AP, Mocumbi AO, Bukhman G.** Cardiovascular diseases in Sub-Saharan Africa compared to high-income countries: an epidemiological perspective. *Global heart*. 2020; 15(1). DOI: <https://doi.org/10.5334/gh.808>
15. **Mocumbi AO, Lameira E, Yakish A,** et al. Challenges on the management of congenital heart disease in developing countries. *International Journal of Cardiology*. 2011; 148: 285–288. DOI: <https://doi.org/10.1016/j.ijcard.2009.11.006>
16. **Murala JSK, Karl TR, Pezzella AT.** Pediatric cardiac surgery in low- and middle-income countries: present status and need for a paradigm shift. *Frontiers in Pediatrics*. 2019; 7: 214. DOI: <https://doi.org/10.3389/fped.2019.00214>
17. **Vervoort D,** et al. Global access to comprehensive care for pediatric and congenital heart disease. *CJC Pediatric and Congenital Heart Disease*. 2023; 2(6): 453–463. DOI: <https://doi.org/10.1016/j.cjpcp.2023.10.001>
18. **Vervoort D, Cardarelli M.** Addressing global disparities in pediatric and congenital cardiac care: introduction to the special series. *AME Surgical Journal*. 10 Feb 2023; 3. DOI: <https://doi.org/10.21037/asj-22-30>
19. **Mohsin S, Hasan B, Zheleva B,** et al. Enhancing quality of congenital heart care within resource-limited settings. *Pediatric Cardiology*. 2023. DOI: <https://doi.org/10.1007/s00246-023-03351-2>
20. **Marshall ME, Jacobs JP, Tretter JT.** Global leadership in pediatric and congenital cardiac care: education and empowerment to improve outcomes in low- and middle-income countries—an interview with Krishna Kumar, MD, DM FAHA. *Cardiology in the Young*. 2023; 33(7): 1071–1078. DOI: <https://doi.org/10.1017/S1047951123001695>
21. **Hasan BS, Bhatti A, Mohsin S,** et al. Recommendations for developing effective and safe pediatric and congenital heart disease services in low-income and middle-income countries: a public health framework. *BMJ Global Health*. 2023; 8: e012049. DOI: <https://doi.org/10.1136/bmjgh-2023-012049>
22. **Curry C, Zuhlke L, Mocumbi A, Kennedy N.** Acquired heart disease in low-income and middle-income countries. *Archives of Disease in Childhood*. 2017. DOI: <https://doi.org/10.1136/archdischild-2016-312521>
23. **Noubiap JJ, Agbor VN, Bigna JJ, Kaze AD, Nyaga UF, Mayosi BM.** Prevalence and progression of rheumatic heart disease: a global systematic review and meta-analysis of population-based echocardiographic studies. *Scientific Reports*. 2019; 9(1): 1–14. DOI: <https://doi.org/10.1038/s41598-019-53540-4>
24. **Ansong AK, Yao N-A, Fynn-Thompson F, Edwin F.** Delivering pediatric cardiac care in sub-Saharan Africa: a model for the developing countries. *Current Opinion in Cardiology*. Jan 2021; 36(1): 89–94. DOI: <https://doi.org/10.1097/HCO.0000000000000801>
25. **Zühlke L, Lawrenson J, Comitis G, De Decker R, Brooks A, Fourie B, Swanson L, Hugo-Hamman C.** Congenital heart disease in low-and lower-middle-income countries: current status and new opportunities. *Current Cardiology Reports*. Dec 2019; 21: 1–3. DOI: <https://doi.org/10.1007/s11886-019-1248-z>
26. **Ma K, He Q, Dou Z, Hou X, Li X, Zhao J, Rao C, Feng Z, Sun K, Chen X, He Y.** Current treatment outcomes of congenital heart disease and future perspectives. *The Lancet Child & Adolescent Health*. 7 Jun 2023. DOI: [https://doi.org/10.1016/S2352-4642\(23\)00076-7](https://doi.org/10.1016/S2352-4642(23)00076-7)

27. **Saxena A.** Pediatric cardiac care in India: current status and the way forward. *Future Cardiology*. Jan 2018; 14(1): 1–4. DOI: <https://doi.org/10.2217/fca-2017-0084>
28. **Saxena A.** Status of pediatric cardiac care in developing countries. *Children*. 25 Feb 2019; 6(2): 34. DOI: <https://doi.org/10.3390/children6020034>
29. **Su Z, Xiang L, Liu Z, Wu H, Li S, Chen H, Zhang H.** The current landscape of congenital heart surgery in northern China: a geographic and population-based analysis. *Frontiers in Pediatrics*. 2021; 9: 555141. DOI: <https://doi.org/10.3389/fped.2021.555141>
30. **Wyber R, Zühlke L, Carapetis J,** et al. The case for global investment in rheumatic heart-disease control. *Bulletin of the World Health Organization*. 2014; 92: 768–770. DOI: <https://doi.org/10.2471/BLT.13.134486>
31. **Jivanji SG, Lubega S, Reel B, Qureshi SA.** Congenital heart disease in East Africa. *Frontiers in Pediatrics*. 26 Jun 2019; 7: 250. DOI: <https://doi.org/10.3389/fped.2019.00250>
32. **Zuechner A, Mhada T, Majani NG, Sharau GG, Mahalu W, Freund MW.** Spectrum of heart diseases in children presenting to a pediatric cardiac echocardiography clinic in the Lake Zone of Tanzania: a 7 years overview. *BMC Cardiovascular Disorders*. 13 Dec 2019; 19(1): 291. PMID: 31835996; PMCID: PMC6909619. DOI: <https://doi.org/10.1186/s12872-019-01292-4>
33. **Sulafa KM, Karani Z.** Diagnosis, management and outcome of heart disease in Sudanese patients. *East African Medical Journal*. 2007; 84: 434–440. DOI: <https://doi.org/10.4314/eamj.v84i9.9553>
34. **Ekure EN, Bode-Thomas F, Sadoh WE, Orogade AA, Otaigbe BE, Ujunwa F,** et al. Congenital heart defects in Nigerian children: preliminary data from the National Pediatric Cardiac Registry. *World Journal of Pediatric Congenital Heart Surgery*. 2017; 8: 699–706. DOI: <https://doi.org/10.1177/2150135117725457>
35. **Aldersley T,** et al. PROTEA, a southern African multicenter congenital heart disease registry and biorepository: rationale, design, and initial results. *Frontiers in Pediatrics*. 20 Oct 2021; 9: 763060. DOI: <https://doi.org/10.3389/fped.2021.763060>
36. **Mazhani T,** et al. Clinical spectrum and prevalence of congenital heart disease in children in Botswana. *Cardiovascular Journal of Africa*. 2020; 31(5): 257–261. DOI: <https://doi.org/10.5830/CVJA-2020-021>
37. **Namuyonga J, Lubega S, Aliku T, Omagino J, Sable C, Lwabi P.** Pattern of congenital heart disease among children presenting to the Uganda Heart Institute, Mulago Hospital: a 7-year review. *African Health Science*. 2020; 20: 745–752. DOI: <https://doi.org/10.4314/ahs.v20i2.26>
38. **Koech M, Ngeno GT, Knettel BA, Jung E, Bloomfield GS.** A profile of demographic, geographic, and socioeconomic risk factors among children with congenital and rheumatic heart disease in western Kenya. *East African Medical Journal*. 2018; 95(8): 1858–1864.
39. **Jacques Cabral TT, Tantchou Tchoumi JC, Butera G.** Profile of cardiac disease in Cameroon and impact on health care services. *Cardiovascular Diagnosis and Therapy*. 2013; 3(4): 236–243. DOI: <https://doi.org/10.3978/j.issn.2223-3652.2013.12.05>
40. **Chinawa AT, Chinawa JM.** Compendium of cardiac diseases among children presenting in tertiary institutions in southern Nigeria: a rising trend. *Libyan Journal of Medicine*. 2021; 16: 1. DOI: <https://doi.org/10.1080/19932820.2021.1966217>
41. **Abdelrahman O, Diab R, Diab RA.** Prevalence and pattern of congenital heart disease among children in Khartoum State, Sudan: a reflection of the current cardiac profile. *Cureus*. 13 Jan 2022; 14(1). DOI: <https://doi.org/10.7759/cureus.21196>
42. **Zikarg YT, Yirdaw CT, Aragie TG.** Prevalence of congenital septal defects among congenital heart defect patients in East Africa: a systematic review and meta-analysis. *Plos one*. 22 Apr 2021; 16(4): e0250006. DOI: <https://doi.org/10.1371/journal.pone.0250006>
43. **Hoffman JI.** The global burden of congenital heart disease. *Cardiovascular Journal of Africa*. 1 May 2013; 24(4): 141–145. DOI: <https://doi.org/10.5830/CVJA-2013-028>
44. **Song L, Wang Y, Wang H, Wang G, Ma N, Meng Q, Zhu K, Hu S, Zhou G, Feng Z.** Clinical profile of congenital heart diseases detected in a tertiary hospital in China: a retrospective analysis. *Frontiers in Cardiovascular Medicine*. 2023; 10. DOI: <https://doi.org/10.3389/fcvm.2023.1131383>
45. **Mir AB, Ahmed K, Jan M, Radakrishnan S.** Spectrum of congenital heart disease in a tertiary care center of Northern India. *International Journal of Contemporary Pediatrics*. May 2019; 6(3): 927. DOI: <https://doi.org/10.18203/2349-3291.ijcp20191996>
46. **Sani MU, Mukhtar-Yola M, Karaye KM.** Spectrum of congenital heart disease in a tropical environment: an echocardiography study. *Journal of the National Medical Association*. Jun 2007; 99(6): 665–669. PMID: 17595936; PMCID: PMC2574369.
47. **Liu Y, Zhu B, Zhuo L, He MY, Xu Y, Wang TT, Cai QQ, Hu B, Xu JC, Zhang WH.** Risk factors for congenital heart disease in Chinese neonates: a meta analysis. *Zhong guo dang dai er ke za zhi (Chinese Journal of Contemporary Pediatrics)*. 1 Jul 2017; 19(7): 754–758.
48. **Ou Y, Mai J, Zhuang J, Liu X, Wu Y, Gao X, Nie Z, Qu Y, Chen J, Kielb C, Lauper U.** Risk factors for different congenital heart defects in Guangdong, China. *Pediatric Research*. Apr 2016; 79(4): 549–558. DOI: <https://doi.org/10.1038/pr.2015.264>

49. **Liu S, Liu J, Tang J, Ji J, Chen J, Liu C.** Environmental risk factors for congenital heart disease in the Shandong Peninsula, China: a hospital-based case-control study. *Journal of Epidemiology*. 5 May 2009; 19(3): 122–130. DOI: <https://doi.org/10.2188/jea.JE20080039>
50. **Bohun CM, Potts JE, Casey BM, George GS, Sandor A.** Population-based study of cardiac malformations and outcomes associated with dextrocardia. *The American Journal of Cardiology*. 2007; 100(2): 305–309. DOI: <https://doi.org/10.1016/j.amjcard.2007.02.095>
51. **Offen S, Jackson D, Canniffe C, Choudhary P, Celemajer DS.** Dextrocardia in adults with congenital heart disease. *Heart, Lung and Circulation*. 2016; 25(4): 352–357. DOI: <https://doi.org/10.1016/j.hlc.2015.09.003>
52. **Sokal R, Tata LJ, Fleming KM.** Sex prevalence of major congenital anomalies in the United Kingdom: a national population-based study and international comparison meta-analysis. *Birth Defects Research, Part A: Clinical and Molecular Teratology*. 2014; 100(2): 79–91. DOI: <https://doi.org/10.1002/bdra.23218>
53. **Yoo BW.** Epidemiology of congenital heart disease with emphasis on sex-related aspects. In *Sex-Specific Analysis of Cardiovascular Function*. Springer; 2018. pp. 49–59. DOI: [https://doi.org/10.1007/978-3-319-77932-4\\_3](https://doi.org/10.1007/978-3-319-77932-4_3)
54. **Remenyi B, Carapetis J, Wyber R, Taubert K, Mayosi BM.** Position statement of the World Heart Federation on the prevention and control of rheumatic heart disease. *Nature Reviews Cardiology*. 2013; 10(5): 284–292. DOI: <https://doi.org/10.1038/nrcardio.2013.34>
55. **Mebrahtom G, Hailay A, Aberhe W, Zereabruk K, Haile T.** Rheumatic heart disease in East Africa: a systematic review and meta-analysis. *International Journal of Rheumatology*. 19 Sep 2023. DOI: <https://doi.org/10.1093/inthealth/ihae011>
56. **Fidel Font LQ, Masanja H, Nathan R, Ascaso C, Menendez C.** Pediatric referrals in rural Tanzania: the Kilombero District Study, a case series. *BMC International Health and Human Rights*. 2002; 2: 4. DOI: <https://doi.org/10.1186/1472-698X-2-4>
57. **Kennedy N, Miller P.** The spectrum of paediatric cardiac disease presenting to an outpatient clinic in Malawi. *BMC Research Notes*. 2013; 6(53). DOI: <https://doi.org/10.1186/1756-0500-6-53>
58. **Sliwa K, Damasceno A, Mayosi BM.** Epidemiology and etiology of cardiomyopathy in Africa. *Circulation*. 2005; 112(23): 3577–3583. DOI: <https://doi.org/10.1161/CIRCULATIONAHA.105.542894>
59. **Animasahun BA, Madise-Wobo AD, Ogunkunle OO, Gbele OH, Oke DA.** Cardiomyopathies among children attending a tertiary hospital in south-western Nigeria. *Journal of Clinical Experimental Research in Cardiology*. 2015; 2(3): 302. DOI: <https://doi.org/10.15744/2394-6504.2.302>
60. **Wang H, Naghavi M, Allen C, et al.** Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980–2015: a systematic analysis for the Global Burden of Disease Study 2015. *The Lancet*. 8 Oct 2016; 388(10053): 1459–1544. DOI: [https://doi.org/10.1016/S0140-6736\(16\)31012-1](https://doi.org/10.1016/S0140-6736(16)31012-1)
61. **Namuyonga J, Mocumbi AO.** Pulmonary hypertension in children across Africa: the silent threat. *International Journal of Pediatrics*. 30 Nov 2021; 2021: 9998070. DOI: <https://doi.org/10.1155/2021/9998070>
62. **Thienemann F, et al.** The causes, treatment, and outcome of pulmonary hypertension in Africa: insights from the Pan African Pulmonary Hypertension Cohort (PAPUCO) registry. *International Journal of Cardiology*. 2016; 221: 205–211. DOI: <https://doi.org/10.1016/j.ijcard.2016.06.242>
63. **Abbaszadeh A, Borhan F.** Barriers of referral system to health care provision in rural societies in Iran. *Manijeh Eskandari (Journal of Caring Sciences)*. 2013; 2(3): 229–236. <http://journals.tbzmed.ac.ir/JCS;doi.org/10.5681/jcs.2013.028>.
64. **Atkinson S, Ngwengwe A, Macwan'gi M, et al.** The referral process and urban health care in sub-Saharan Africa: the case of Lusaka, Zambia. *Social Science & Medicine*. 1999; 49(1): 27–38. DOI: [https://doi.org/10.1016/S0277-9536\(99\)00072-6](https://doi.org/10.1016/S0277-9536(99)00072-6)
65. **Murugan SJ, Thomson J, Parsons JM, Dickinson DF, Blackburn MEC, Gibbs JL.** New outpatient referrals to a tertiary pediatric cardiac center: evidence of increasing workload and evolving patterns of referral. *Cardiology in the Young*. 2005; 15: 43–46. DOI: <https://doi.org/10.1017/S1047951105000090>
66. **Kostopoulou E, Dimitriou G, Karatza A.** Cardiac murmurs in children: a challenge for the primary care physician. *Current Pediatric Reviews*. 2019; 15(3): 131–138. PMID: 30907325. DOI: <https://doi.org/10.2174/1573396315666190321105536>
67. **Germanakis I, Petridou ET, Varlamis G, Matsoukis IL, Papadopoulou-Legbelou K, Kalmanti M.** Skills of primary healthcare physicians in pediatric cardiac auscultation. *Acta Paediatrica*. 2012; 102(2): e74–78. DOI: <https://doi.org/10.1111/apa.12062>
68. **Alabdaljabar MS, Hasan B, Noseworthy PA, Maalouf JF, Ammash NM, Hashmi SK.** Machine learning in cardiology: a potential real-world solution in low- and middle-income countries. *Journal of Multidisciplinary Healthcare*. 2023; 16: 285–295. DOI: <https://doi.org/10.2147/JMDH.S383810>

69. **Wang J, You T, Yi K, Gong Y, Xie Q, Qu F, Wang B, He Z.** Intelligent diagnosis of heart murmurs in children with congenital heart disease. *Journal of Healthcare Engineering*. 2020; 2020: 1–9. DOI: <https://doi.org/10.1155/2020/9640821>
70. **James M, Poornima KN, Ninan PJ.** Evaluation of children with cardiac murmur using Nadas criteria. *International Journal of Contemporary Pediatrics*. 2018; 5: 363–367. DOI: <https://doi.org/10.18203/2349-3291.ijcp20180406>
71. **Izhar FM, Abqari S, Shahab T, Ali SM.** Clinical score to detect congenital heart defects: concept of second screening. *Annals of Pediatric Cardiology*. Oct–Dec 2020; 13(4): 281–288. Epub 1 Sep 2020; PMID: 33311915; PMCID: PMC7727906. DOI: [https://doi.org/10.4103/apc.APC\\_113\\_19](https://doi.org/10.4103/apc.APC_113_19)
72. **Rodríguez-González M, Alonso-Ojembarrena A, Castellano-Martínez A, Estepa-Pedregosa L, Benavente-Fernández I, Lubián López SP.** Heart murmur in children under 2 years of age: looking for a safe and effective referral strategy. *Anales de Pediatría (Barcelona)*. 2018; 89: 286–293. *Journal of the American College of Cardiology*. 2014; 64(19): 2039–2060. DOI: <https://doi.org/10.1016/j.anpede.2018.01.012>
73. **Nair SM, Zheleva B, Dobrzycka A, Hesslein P, Sadanandan R, Kumar RK.** A population health approach to address the burden of congenital heart disease in Kerala, India. *Global Heart*. 2021; 16(1). DOI: <https://doi.org/10.5334/gh.1034>

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