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FELLOWS FORUM

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Pattern of inpatient pediatric cardiology consultations in sub-Saharan Africa

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Abstract

Malawi is one of the poorest nations in the world, ranked 151st among 195 countries by the World Bank, with an under-5-year mortality rate of 63 per 1000 live births. There are no previous studies describing the spectrum of inpatient pediatric cardiology consultations in sub-Saharan Africa. A descriptive cohort study was performed at Kamuzu Central Hospital (KCH), a tertiary care hospital in Lilongwe, Malawi. Demographic, anthropometric, and clinical information for all cardiology consults patients aged 0–18 years admitted to the children's wards over a period of 1 month was reviewed. Seventy-three consults and 69 echocardiograms were performed on 71 patients (35 males, 38 females). The median (IQR) age was 3.1 years (9 months–10.5 years). About 53% (39/73) had failure to thrive, 4.1% (3/73) were sero-reactive for HIV and 100% (73/73) were fully immunized for age per the Expanded Program on Immunization schedule. Seventy-four percent of the echocardiograms were abnormal, with 34.8% (24/69) having congenital heart disease (CHD) and 18.8% (13/69) having acquired heart disease (AHD) with preserved cardiac function. Among CHD, 10.1% (7/69) had cyanotic CHD and 24.6% (17/769 had acyanotic CHD. Among AHD, 10.1% (7/69) had rheumatic heart disease with preserved cardiac function. Symptomatic systolic heart failure (HF) with ejection fraction <50%, was found in 20.3% (14/69), and pulmonary hypertension was diagnosed in 10.1% (7/69). Overall admission mortality was 5.5% (4/73). Three patients left the hospital against medical advice. None of the patients with systolic HF had CHD. There was no significant association of HIV, gender, or failure to thrive on presence of systolic HF. This is the first report describing the spectrum of pediatric cardiology consults in an inpatient setting in Malawi. There was an unexpectedly high proportion of CHD and systolic HF. Further studies should be conducted to explore the implications and potential causes of these findings.

KEYWORDS
Africa, echocardiography, global health, pediatric cardiology, resource-limited

1 | INTRODUCTION

The spectrum of cardiovascular disease admitted to pediatric wards in low and middle income countries (LMICs) differs from what is known in more resourced settings. Prenatal diagnosis is at a very nascent stage, so most structural heart disease diagnoses are made postnatally. Further, electronic medical records are limited, and maintenance and transmission of medical records from one care encounter to another is challenging.[1–3] The care of the pediatric cardiac patient is also complicated by factors such as malnutrition, and comorbid infectious conditions, such as HIV and tuberculosis. The overwhelming majority of literature reported from resource-limited centers is from upper middle income countries like India, Brazil, and South Africa, where there is diagnostic expertise, as well as in-country cardiac surgery. However, the pattern of cardiac disease presentation and management at hospitals in a low income nations where there currently are no in-country pediatric cardiologists or cardiac surgeons and there is limited access to healthcare and medications, is very different. In addition, the pattern of

cardiac disease admitted to hospitals in low income countries, as well as the economic burden of these cardiac admissions on the healthcare centers is not well-characterized. This lack of characterization limits planning or policymaking toward addressing pediatric cardiovascular care in this setting.[4]

Our aim was to characterize the pediatric cardiology consults for patients admitted to the hospital over a 1-month period. We hypothesized that a majority of the patients with cardiac disease that are consulted on will have acquired cardiac disease, with the predominance of rheumatic heart disease (RHD).

2 | METHODS

We performed a descriptive needs assessment cohort study based on our experience on the cardiology consult service at Kamuzu Central Hospital (KCH) in Lilongwe, the capital of Malawi. KCH is an urban tertiary level referral hospital, affiliated with the University of Malawi Medical School. It has capacity for 600–1000 patients (often multiple patients on single bed). Based on the 2015 census, there are approximately 1715 monthly admissions to the pediatric wards at KCH, with a 3.1% (53/1715) mortality rate, and about 226 monthly newborn nursery and neonatal intensive care unit (NICU) admissions with approximately 16% (36/226) mortality rate among these infants. The pediatric wards are divided into different zones of acuity and specialty. The emergency zone (EZ) is the highest acuity zone similar to a trauma area in an emergency room, where the sickest patients are brought in and stabilized. After that, the patients may either be moved to the high dependency unit (HDU) with 7 beds, or remain in the EZ (total 26 beds). Only the EZ and the HDU have capability to administer infusions and positive pressure ventilation (PPV) through continuous positive airway pressure. Mechanical ventilation is done only in the adult ICU. Patients who are transitioned off PPV, however, still needing close monitoring with either oxygen therapy or parenteral antibiotics are transferred to the Red Zone (age $>$ 6 months up to 3 years) which has 22 cribs, or to the Nursery (age $\leq$ 6 months) which has 15 cribs. Patients 6 months of age or younger stay in the Nursery to be weaned off support until time of discharge. Patients who are older than 3 years of age may then be transferred to the Children's General Ward (total 70 beds) once they are off oxygen therapies, but still need hospitalization for parenteral medications prior to discharge. Children born in the Ethel Mutharika Maternity Wing of KCH or newborns presenting to the ER needing PPV were admitted to the Ethel Mutharika Nursery and Neonatal Intensive Care Unit (NICU) which has 21 beds. Patients in the NICU who were weaned off PPV could be moved to the Low Risk Ward or the Kangaroo Ward (within the Ethel Mutharika Nursery/NICU complex) for further management till discharge. There is also a special Nutritional Rehabilitation Unit (NRU) with 8 beds where patients suffering from severe acute or chronic malnutrition are admitted once they are off PPV. Surgical patients were typically directly admitted to the Children's General Ward after observation in the Recovery Room. There is also a section of Oncology patients within the Children's General Ward. It is noteworthy that each bed typically may admit 4–5 patients, while each crib may admit 3–4 patients, except in the HDU and the NICU where each bed or crib holds only 1 patient. This allows the total capacity of the Children's Ward at KCH to be up to 700 patients at a time, although the typical pediatric census ranges from 450 to 550 patients.

The study was approved by the Institutional Review Board at Baylor College of Medicine and the National Health Sciences Research Committee in Malawi. Authors KP and AES were visiting physicians at KCH during the month of February 2017, and performed as the pediatric cardiology consult team along with TM (one of the authors—a Malawian clinical officer who is being informally trained in cardiology and echocardiography). All cardiology consults for patients aged 0 to 18 years admitted to the Children's Ward at KCH during the month of February 2017 are included in the study. Demographic and anthropometric information, including history of presenting illness, past history of cardiac problems, echocardiograms, and medical/surgical history was obtained. The reason for cardiology consultation was recorded—concern for CHD associated with genetic syndrome, cyanosis concerning for cyanotic CHD, symptoms concerning for pulmonary overcirculation or acyanotic CHD or HF, history of RHD, concern for pulmonary hypertension, and others. A cardiology consultation was completed, and a complete echocardiogram was performed if indicated (rated "appropriate" as per the appropriate use criteria).[5] A Philips (Andover, MA, USA) CX-50 echocardiogram machine was used to perform echocardiograms. All consults were performed by KP and supervised and reviewed by AES, and assessment and recommendations communicated to the primary providing physician. Recommendations of the consult team, as well as daily progress of the patients on the consultation list were followed and recorded. Dates of admission and discharge, outcome of index hospitalization, and clinic follow-up, when available, were recorded and reviewed.

2.1 | Statistics

Demographics, symptoms of presentation, and admission characteristics of patients were analyzed and reported. SPSS 22.0 (chi-square, Fisher's exact, Mann-Whitney's *U*-tests, as indicated) software package was used for statistical analysis.

3 | RESULTS

There was a total of 1623 admissions during the 4 week period. Seventy three inpatient consults were performed on 71 patients in the 4 week duration. Among these, 69 echocardiograms were performed. During this month, only 3 pediatric echocardiograms were carried out in the Division of Radiology. Images of the echocardiograms performed by the Division of Radiology are not typically archived at KCH, however, the overall impression is recorded. Of these 3 echocardiograms, 2 were normal while 1 was recorded to be showing "left ventricular hypertrophy."

TABLE 1 Demographic features of study cohort

Characteristic	*N* = 73
Age, median (IQR)	3.1 y (9 mo –10.5 y)
Sex	
Male, *n* (%)	35 (47.9)
Female, *n* (%)	38 (52.1)
Weight (kg), median (IQR)	10 (5.6–21)
Immunization, *n* (%)	73 (100)
History of cardiac disease, *n* (%)	20 (27.4)
Failure to thrive, *n* (%)	39 (53.4)
HIV-reactive, *n* (%)	3 (4.1)
Malaria spot test positive, *n* (%)	5 (6.8)
Down syndrome, *n* (%)	10 (13.7)
Clinical suspicion for other syndromes, *n* (%)	3 (4.2)
Past echocardiogram	*N* = 73
By cardiologist, *n* (%)	2 (2.7)
By radiologist, *n* (%)	18 (24.7)
None, *n* (%)	53 (72.6)
Reason for consultation	*N*=73
Screening for syndrome, *n* (%)	4 (5.5)
Cyanotic CHD, *n* (%)	11 (15.1)
Systolic HF or pulmonary overcirculation/ acyanotic CHD, *n* (%)	48 (65.8)
Pulmonary hypertension, *n* (%)	1 (1.4)
History of rheumatic heart disease, *n* (%)	6 (8.2)
Concern for vegetation causing hemolysis, *n* (%)	1 (1.4)
Irregular rhythm, *n* (%)	2 (2.7)
Echocardiogram Indicated, *n* (%)	69 (94.5)

Abbreviations: CHD, congenital heart disease; HF, heart failure.

TABLE 2 Echocardiogram results for study cohort

Diagnoses, *N* (%)	*N* = 69
Normal echocardiogram	18 (26.1)
Congenital heart disease	
Cyanotic heart disease	7 (10.1)
Tetralogy of Fallot	3
With PS	2
With PA	1
Transposition of the great arteries (+ASD, +VSD)	1
Anomalous pulmonary venous return	2
Total	1
Partial	1
Truncus arteriosus	1
Acyanotic Heart Disease	17 (24.6)
Endocardial cushion defects	5
Complete AVSD	4
Primum ASD with cleft MV	1
Ventricular septal defect	4
Double outlet right ventricle	1
Patent ductus arteriosus	2
Dysplastic MV	1
Subaortic Membrane + Bicuspid Aortic Valve	1
Pulmonary hypertension	7 (10.1)
Acquired heart disease	
Rheumatic heart disease	7 (10.1)
Systolic ventricular dysfunction	14 (20.3)
Pericardial effusion	3 (4.3)
Supra-physiologic valvar regurgitation	3 (4.3)

Abbreviations: PS, pulmonary stenosis; PA, pulmonary atresia; ASD, atrial septal defect; VSD, ventricular septal defect; AVSD, atrioventricular septal defect; MV, mitral valve.

3.1 | Consult demographics

The demographic features of the study cohort and the reasons for consultation are depicted in Table 1. The population was equitably distributed between genders (35 males, 38 females), and all of them were immunized up to date for age per the World Health Organization's immunization schedule. The median (IQR) age of the cohort was 3.1 years (9 months to 10.5 years), and the median (IQR) weight was 10 kg (5.6–21). About 53% (39/73) had failure to thrive (defined as weight for length less than third percentile for age), and 4.1% (3/73) were sero-reactive for HIV (all of the patients in the study cohort were tested for HIV). Almost 14% (10/73) had Down syndrome, while 4.25 (3/73) had concern for other genetic syndromes on physical exam. A majority of the consults were from high acuity sections of the Children's Ward—61.6% (45/73) from the EZ, 13.7% (10/73) from the NICU. The remaining comprised 17.8% (13/73) from the Children's General Ward, 5.5% (4/73) from the Nutritional Rehabilitation Unit, and 1.4% (1/73) from the Nursery. Of the 20 patients who had had echocardiograms in the past, only 2 had been done by a cardiologist.

3.2 | Consult findings and recommendations

The diagnostic details of the study cohort are also listed in Table 2. The majority of the patients consulted on had cardiac disease (74%, 54/73; Tables 2 and 3). Of the 69 patients who underwent echocardiograms, 34.8% (24/69) had CHD and 18.8% (13/69) had acquired heart disease (not including depressed cardiac function). Interestingly, 20.3% (14/69) had depressed cardiac function (including 1 newborn), all of whom also had symptoms of heart failure (tachypnea, tachycardia, diaphoresis, hepatomegaly, failure to thrive), and were hence classified as systolic heart failure (HF). Overall, 14.5% (20/69) of the patients had features of pulmonary hypertension.

A vast majority of the patients (total 14) diagnosed with systolic HF were new diagnoses, with only 20% (3/14) having preexisting diagnoses of systolic HF. Of these, a majority (12/14) of the consults were requested due to concern for either pulmonary overcirculation/acyanotic CHD or systolic HF, while there was concern for cyanotic heart disease and rheumatic heart disease in one patient each. Demographic and clinical details of these patients in comparison to the rest of the cohort are shown in Table 3. A majority of the admissions were to the EZ (10/14), while 3 patients were admitted to the NICU and 1 patient was admitted in the Nursery. None of the patients with systolic HF had CHD. In this cohort, 14% (2/14) of the patients had HIV and 50% (7/14) had failure to thrive. There was no significant gender predilection for systolic HF. Children with systolic HF were significantly larger in weight, and their median age also tended toward higher than those with normal function (however, did not achieve significance). There was no significant

TABLE 3 Characteristics of patients with systolic heart failure in comparison to remainder of the study cohort

Characteristic	Depressed function ($n = 14$)	Normal function ($n = 55$)	*P* value	OR (95% CI)
Male sex, *n* (%)	7 (50.0)	27 (49.1)	1	1.04 (0.321–3.353)
Age at admission in years (median, IQR)	4.28 (2.3–10.8)	2.26 (0.6–9.6)	.199	
Weight in kg (median, IQR)	13.8 (10.6–28)	8.0 (5.4–20.0)	**.032**	
Past history of cardiac problem, *n* (%)	5.0 (35.7)	12.0 (21.8)	.309	1.99 (0.561–7.066)
Immunized, *n* (%)	14.0 (100.0)	55.0 (100.0)	N.A.	
HIV reactive, *n* (%)	1.0 (7.1)	2.0 (3.6)	.499	2.04 (0.171–24.243)
Malaria spot–test positive, *n* (%)	1.0 (7.1)	4.0 (7.3)	1	1.09 (0.107–11.152)
Physical Exam Finding				
Failure to thrive, *n* (%)	7.0 (50.0)	29.0 (52.7)	.855	0.90 (0.277–2.900)
Tachycardia, *n* (%)	13.0 (92.8)	29.0 (52.7)	**.006**	11.66 (1.425–95.341)
Tachypnea, *n* (%)	13.0 (92.8)	41.0 (74.5)	.274	4.44 (0.531–37.075)
Fever, *n* (%)	2.0 (14.3)	16.0 (29.1)	.260	0.41 (0.082–2.024)
Delayed capillary refill, *n* (%)	3.0 (21.4)	1.0 (1.8)	**.024**	14.73 (1.399–155.075)
Hepatomegaly, *n* (%)	11.0 (78.6)	22.0 (40)	**.010**	5.50 (1.376–21.991)
Gallop, *n* (%)	10.0 (71.4)	5.0 (9.1)	**<.001**	25.00 (5.692–109.795)
Murmur, *n* (%)	3.0 (21.4)	32.0 (58.2)	**.014**	0.20 (0.049–0.783)
Cyanosis, *n* (%)	2.0 (14.3)	16.0 (29.1)	.327	0.41 (0.082–2.024)
Medication Change				
Diuretics, *n* (%)	13.0 (92.8)	19.0 (34.5)	**<.001**	24.63 (2.991–202.866)
Inotropes/vasoactives, *n* (%)	5.0 (35.7)	1.0 (1.8)	**.001**	30.00 (3.130–287.500)
Afterload reduction, *n* (%)	11.0 (78.6)	7.0 (12.7)	**<.001**	25.14 (5.594–113.030)
Aspirin, *n* (%)	10.0 (71.4)	7.0 (12.7)	**<.001**	17.14 (4.207–69.849)
Outcomes				
Mortality, *n* (%)	1.0 (7.1)	3.0 (5.4)	1.000	1.33 (0.128–13.888)
Duration of admission in days, median (IQR)	6.0 (2.8–9.3)	6.0 (3.0–14.0)	.784	

association of HIV or failure to thrive on presence of systolic HF. Children with systolic HF were significantly more likely to be tachycardic (OR 11.6, 95% CI 1.4–95.3) and have hepatomegaly (OR 5.5, 95% CI 1.4–22.0) and S3 gallop (OR 25, 95% CI 5.7–109.8) on initial physical examination at time of consultation. They were also more likely to have features of poor perfusion indicated by delayed capillary refill (OR 14.7, 95% CI 1.4–155.1). As may be expected, they were more likely to be initiated on diuretics ($P < .001$), afterload reducing agents ($P < .001$), aspirin ($P < .001$), and vasoactive agents/inotropes ($P = .001$). There was no significant difference in mortality of patients with systolic HF and the rest of the sample.

Based on cardiology consult recommendations, 56.2% (41/73) patients were started or uptitrated on medications, and surgical referral was made for 12.3% (9/73) patients. It is worth noting that due to the national policy of not externally referring patients who have genetic syndromes or need multiple stages of surgical palliation for their heart disease, 21.9% (16/73) patients had surgical lesions that were not be referred for surgery.

3.3 | Clinical outcomes

The overall median (IQR) total length of admission was 5 days (3–10.5 days). A majority of patients (60%, 44/73) were discharged more than 72 hours after consultation, while 30% (22/73) were discharged within 72 hours of consultation. Two patients (2.7%) died within 24 hours of consultation, 1 patient who was a newborn with hypertrophic cardiomyopathy on echocardiogram, and likely an unconfirmed metabolic disorder, while the other was a child with severe respiratory distress who had a structurally normal heart on echocardiogram. Another 2 patients (2.7%) died more than 24 hours after consultation. One of these was a patient with unrepaired total anomalous pulmonary venous return with a restrictive atrial septum and features of poor cardiac output. The second one was a patient with severe anemia and elevated markers of hemolysis and inflammation (high LDH and ferritin levels), who had normal cardiac anatomy with no vegetations, but had echobright myocardium with mildly depressed ventricular function. Follow-up was arranged for 56.2% (41/73) patients at the weekly cardiology clinic at KCH. Three patients (4%) left the hospital against medical advice (1 within 24 hours of consultation and the other 2 more than 72 hours after consultation) and were lost to follow-up.

3.4 | Adverse outcomes

Detailed characteristics of the 4 patients who succumbed in the hospital admission are shown in Table 4. Consult was requested for concern about cyanotic heart disease in 3 of the patients, and for concern about vegetation in 1 patient. There was no specific gender predilection of patients who died, and there was no difference in age at admission or weight among the two groups. The group that died was more likely to demonstrate poor capillary refill ($P = .013$) and cyanosis ($P = .044$) on physical examination at time of consultation.

4 | DISCUSSION

This report is the first study to describe the spectrum of pediatric cardiology inpatient consults in Malawi. A majority of the patients who

TABLE 4 Characteristics of patients who died during admission in comparison to remainder of study cohort

Characteristic	Died ($n = 4$)	Survived ($n = 69$)	*P* value	OR (95% CI)
Male sex, *n* (%)	2.0 (50.0)	28 (40.6)	1.000	0.68 (0.088–5.243)
Age at admission in years (median, IQR)	0.5 (0.0–11.6)	3.0 (0.8–9.6)	.240	
Weight in kg (median, IQR)	5.1 (2.7–19.4)	10.0 (6.0–21.0)	.163	
Past history of cardiac problem, *n* (%)	1.0 (25.0)	19.0 (27.5)	1.000	0.88 (0.086–8.962)
Immunized, *n* (%)	4.0 (100.0)	69.0 (100.0)	N.A.	
HIV, *n* (%)	0 (0)	3.0 (4.3)	1.000	0.94 (0.890–0.999)
Physical exam and echo finding				
Failure to thrive, *n* (%)	1.0 (25.0)	38 (55.1)	0.333	0.27 (0.027–2.746)
Tachycardia, *n* (%)	4.0 (100.0)	33.0 (47.8)	0.147	1.10 (1.002–1.208)
Tachypnea, *n* (%)	3.0 (75.0)	42.0 (60.9)	1.000	0.83 (0.081–8.602)
Fever, *n* (%)	2.0 (50.0)	17.0 (24.6)	0.276	3.06 (0.400–23.407)
Delayed capillary refill, *n* (%)	2.0 (50.0)	2.0 (2.9)	**0.013**	33.50 (3.002–373.820)
Hepatomegaly, *n* (%)	2.0 (50.0)	27.0 (39.1)	1.000	1.16 (0.154–8.684)
Gallop, *n* (%)	0 (0)	15 (21.7)	0.575	0.93 (0.868–0.999)
Murmur, *n* (%)	2.0 (50.0)	36.0 (52.2)	1.000	0.92 (0.122–6.883)
Cyanosis, *n* (%)	3.0 (75.0)	15.0 (21.7)	**0.044**	10.80 (1.046–111.485)
Presence of cardiac disease, *n* (%)	4.0 (100.0)	47.0 (68.1)	0.566	1.09 (1.002–1.176)
Depressed cardiac function on echo, *n* (%)	1.0 (25.0)	13.0 (18.8)	1.000	1.33 (0.128–13.888)
Medication change				
Diuretics, *n* (%)	0 (0)	34.0 (49.3)	0.117	0.89 (0.802–0.998)
Inotropes/vasoactives, *n* (%)	1.0 (25.0)	5.0 (7.2)	0.299	4.20 (0.366–48.163)
Afterload reduction, *n* (%)	0 (0)	19.0 (27.5)	0.567	0.93 (0.856–0.998)
Rate control agents, *n* (%)	0 (0)	8.0 (11.6)	1.000	0.94 (0.880– 0.999)
Aspirin, *n* (%)	0 (0)	17.0 (24.6)	0.566	0.93 (0.861–0.999)
Penicillin, *n* (%)	0 (0)	8.0 (11.6)	1.000	0.97 (0.901–1.034)
Secondary outcome				
Duration of admission in days (median, IQR)	3.5 (1.3–11.8)	6.0 (3.0–10.5)	0.373	

received consultation had cardiac pathology, with a similar proportion of CHD and AHD. Overall, the leading diagnoses were CHD (34.6%) and HF with systolic dysfunction (20.3%). Further, RHD was found in 10.1% of the consults, with similar proportion (10.1%) having pulmonary hypertension. The management and monitoring of common noncommunicable cardiac conditions like CHD remains extremely difficult to afford in LMICs. Due to limited resources, lack of on-the-ground cardiology expertise, and a high burden of infectious disease and acute illness, a different pattern of pediatric cardiac disease presentation and time course exists when compared to more resourced settings. Patient access to health care may be more limited, medications may not be readily available, and there may be no option for an in-country surgical intervention.

The burden of cardiovascular diseases in LMICs is increasing, especially as the infant and under-5-year mortality rates improve.[6] There are no previous studies describing or quantifying the burden of cardiac disease on the inpatient services of adult or pediatric hospitals in Malawi. With no in-country cardiac surgery or pediatric cardiologist, the diagnosis and care of cardiac patients especially among the pediatric population is very challenging. Among the limited previous literature, the earliest report from Brown et al. who conducted a prospective clinical study of 114 Malawian patients with cardiac disease seen at Queen Elizabeth Central Hospital, Blantyre (1975).[7] The authors found that rheumatic and hypertensive heart disease, cardiorenal failure, and severe anemia were the most common causes of cardiac disease seen in their community. Our findings differ from Brown et al., maybe due to the bias of starkly different era, as the infant and under-5-year mortality rate has dropped considerably since 1975, and access to health care is improving. In a more recent report from Soliman et al. at the Mzuzu Central Hospital outpatient Cardiology Clinic, from the years 2001 to 2005, out of the 3908 new Malawian patients, 34% had valvular heart disease (mainly RHD); 24%, hypertensive heart disease; 19%, cardiomyopathies; and 14%, pericardial diseases.[8] The other cardiovascular disease patterns included congenital heart disease and arrhythmias, each representing 4% of the registered patients. In another recent study by Kennedy et al. in 2013, at the outpatient pediatric cardiology clinic in Blantyre, of the 250 children with abnormal echocardiograms, 139 (55.6%) had congenital heart disease, and 111 (44.4%) acquired heart disease.[9] Ventricular septal defect (24%), tetralogy of Fallot (10%), and patent ductus arteriosus (7.2%) were the commonest forms of CHD. RHD (22.4%) and dilated cardiomyopathy (13.6%) were the commonest acquired diseases. Our study was in an inpatient setting, and the proportion of RHD was 10.1%, which was less than that of CHD or systolic HF. This may indicate improving symptomatic management of RHD on an outpatient basis, or under-detection and mortality in the community.

A previous study by Geggel et al. from the Children's Hospital of Boston described 2071 pediatric cardiology consultations on 1724 patients.[10] About one-fifth of the burden was due to murmurs which comprised the highest proportion. Concern about depressed cardiac function accounted for about 12.5% of the consults, and cyanosis was the reason for consultation in about 6.3%. In comparison, in our study,

there was a higher proportion of consults for cyanosis (15.1%). There was concern for either depressed cardiac function or pulmonary overcirculation in about 2/3rds of the consults. This was due to the prevalence of RHD and associated mitral regurgitation which might potentially have physical examination findings similar to a left-to-right shunting lesion like a ventricular septal defect. Geggel et al. found that the most common sites of consultation were the NICU and known cardiac patients presenting to the emergency room, while the pediatric ICU was a less common site of consults. In our experience, we encountered a majority of our consults from the EZ, which can be considered comparable in acuity to intensive care units or progressive care units in the hospitals in the United States.

The distribution of cardiac pathology was notable for a higher proportion of systolic HF and ventricular dysfunction than previously reported in Geggel et al.'s study, albeit the latter was from a tertiary pediatric hospital in the United States.[10] There is scant other data describing the proportion of the systolic HF among pediatric cardiology consultations. A retrospective study from Ogeng'o et al. from Kenya reviewed all patients aged 12 years and younger admitted for HF, over a period of 5 years, and found 158 cases.[11] In contrast, we encountered 14 admissions for systolic HF in a single month, which would project a significantly higher number of patients over a 5-year period. The mortality of patients with systolic HF in our study was 7.1% which is comparable to the 7.6% reported by Ogeng'o et al., as well as 7.4% reported by Rossano et al. in their database study looking at admissions in the years 1997, 2000, 2003, and 2006.[11,12] The median length of stay in our study was 6 days which is slightly lower than the mean duration of admission reported by Rossano et al. which ranged from 13.8 days in 1997 to 19.4 days in 2003.[12] Interestingly, sicker patients may have never made it to the hospital, suggesting that the numbers are even higher. Further, in our population, the median age of a patient with systolic HF was about 4.3 years, with the youngest patient being 5-week old and only 2 patients in the infant age group. None of our patients with systolic HF had CHD. Rossano et al.'s study found over 50% of the systolic HF admissions to be infants, and over 60% had CHD, both of these being cohorts of patients who understandably may have longer durations of admission.[12]

The higher proportion of systolic HF among pediatric inpatient consultations is especially relevant on two fronts. For one, a significant component of systolic HF management is medical therapy with diuretics and afterload reducing agents. Generic hydrochlorthiazide, furosemide, and captopril are available in Malawi. In addition, these patients are initiated on aspirin for anticoagulation due to the blood stasis in the setting of ventricular dysfunction. However, these routine medications may not be easy to obtain in LMICs due to the financial burden put on families. In their study, assessing the affordability of medications in western Cameroon, Jingi et al. showed that only hydrochlorthiazide (0.17 days' wage), furosemide (0.17 days' wage), and aspirin (0.03 days' wage) were affordable for one month's treatment on less than one day's wage in Cameroon.[13] Further, their study found that a month's supply of captopril was equivalent to 6.4 days' wage, which is significant in a low income setting.

Second, studies in adults in diverse settings have shown that systolic HF is associated with various nutritional deficiencies including thiamine, folate, vitamin D, selenium, and iron.[14–16] Patients with nutritional deficiencies have been shown to have poorer outcomes, possibly due to the role of micronutrients in cell cycle energetics.[17,18] Further nutritional interventions to replete these deficiencies have been shown to reduce mortality among patients admitted with systolic HF.[19,20] This is a concerning fact considering the systolic HF patients in Malawi, which is one of the poorest nations in the world.[21] About 46% of the children under 5 years of age in Malawi are stunted and 21% are underweight.[22] While we did not find an association of mortality with failure to thrive in our study, our results are limited by a small sample size. Assessment of caloric and nutritional deficiencies, and fortification and repletion therapy is now a frontline recommendation for systolic HF management in more resource-equipped settings.[23] This is also an important goal to consider when managing these patients in Malawi, where the existing programs to monitor and closely manage malnutrition can be applied to the patients in systolic HF as well.

In our cohort, only 2 patients with depressed ventricular function were HIV positive, both of whom were on antiretroviral therapy. In these small numbers, we did not find any association of HIV positive testing with HF. Sanyahumbi et al. have also previously shown that there is no significant difference in the ejection fraction or shortening fraction between patients with and without HIV in the Malawian population.[24]

Our study has generated data with several interesting trends. The higher incidence of CHD as well as systolic HF is ripe for further investigation. Observational study over a longer duration of time, and incorporating the outpatient experience (currently KCH has one day of cardiology clinic a week) would allow for more accurate needs-estimation of the inpatient burden of cardiology and the medicines required. This would be critical for the process of resource allocation of the aid acquired by the hospital. Sanyahumbi et al. have shown that relatively short courses of training (3 half-days of didactics and 2 full days of hands-on echocardiography training) enable clinical officers in Malawi to detect patients who would benefit from referral for assessment of RHD with reasonable sensitivity.[25] Similar directed training modules for screening for the commonly encountered lesions (for e g., endocardial cushion defects, ventricular septal defects and tetralogy of Fallot) would allow more timely surgical referral for repair, a process which unfortunately involves unpredictable and prolonged waiting durations from a few months to over an year. These modules may also train individuals to better manage symptoms with early initiation of medical therapies (like diuretics, beta-blockers, and ACE inhibitors) for patients with these lesions, and enable better nutritional optimization while they await surgical intervention. The high proportion of systolic HF patients is especially significant in terms of development of education strategies and policies. If the figures from Malawi are an indication for a larger portion of sub-Saharan Africa, systolic HF diagnosis, and management may benefit greatly from more education of the clinical officers and pediatric staff. While in-country heart surgery may be years or even decades away, better resource allocation for improving the quality of life, functionality and survival of systolic HF patients may

be easier to achieve. Barring mechanical circulatory support and heart transplantation, the medications used to manage systolic HF in developed nations like diuretics and cardiac remodeling agents are, for the most, also available in Malawi. Improving accessibility of the families to these medications, and short-term training for assessment of systolic ventricular function would greatly improve the care of these patients. Nutritional assessment of the patients in systolic HF will allow for identification of potential therapeutic targets for nutritional interventions, and for improving survival of this cohort of patients which accounts for a significant proportion of cardiac pathology in the country.

4.1 | Limitations

Our study was limited by its duration of one month and the small sample size. We may have missed patients that presented in extremis, or those in which the need for cardiology consultation was not recognized. The request for cardiology consultation was based on clinical suspicion of the clinical staff in the hospital. Due to extremely limited laboratory testing abilities, we were not able to test for possible infectious or nutritional causes or other precipitating factors of heart failure.

5 | CONCLUSIONS

We describe the spectrum of pediatric consultations in an inpatient setting in a tertiary hospital in Malawi. Over 70% of the consultations yielded cardiac pathology, with a majority comprised of CHD and HF. RHD comprised about 10% of the cohort. The overall hospital mortality of the study cohort was 6%.

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CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTIONS

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Collected the data, carried out the initial analyses, drafted the initial manuscript, and reviewed and revised the manuscript: Puri, Mkaliainga, Sanyahumbi

Designed the data collection instruments, and coordinated and supervised data collection, and critically reviewed the manuscript: Puri, Kazembe, Chiume, Sanyahumbi

Coordinated and supervised data collection, supervised analysis, and critically reviewed and revised the manuscript: Kazembe, Mkaliainga, Chiume, Cabrera, Sanyahumbi

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