CONGENITAL CARDIOLOGY TODAY
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Prevalence of Wasting, Stunting, Underweight and Associated Factors Among Children Under Five Years with Uncorrected Congenital Heart Disease at Mbarara Regional Referral Hospital, Mbarara, Uganda

Ibrahim Yusuf Hassan, MD; Longes Doreen Faith, MD; Mwinike Yusuf, MD; Namiiro Agnes, MD; Fiona Tagema, MD; Dorah Nampijja, MD; Nantongo Josephine, MD

Abstract

Background: Children with Congenital Heart Disease (CHD) are at increased risk of undernutrition compared to healthy children. CHD is most prevalent in developing nations, and the majority of these children receive inadequate or no care at all. Their risk of undernutrition may be even increased by socioeconomic factors such as delays in seeking health care, delayed diagnosis and interventions, larger households, cultural norms and practices. The burden and associated factors of undernutrition among children with congenital heart disease are not yet well investigated in our setting. Therefore, this study aimed to determine the prevalence and associated factors of undernutrition among children ≤ 5 years with uncorrected Congenital Heart Disease attending the pediatric cardiac clinic at Mbarara Regional Referral Hospital.

Methods: We conducted a hospital-based cross-sectional study among 103 children with congenital heart disease presenting to the pediatric outpatient cardiac clinic of Mbarara Regional Referral Hospital. Participants were consecutively enrolled from March to August of 2023. With a structured interviewer-administered questionnaire, we looked at child, caretaker, medical and nutritional factors and assessed the anthropometric measurements. Statistical significance was set at p-value 0.05, and multivariate logistic regression was used to determine the associated factors.

Results: A total of 103 patients participated in the study. Over three-quarters of the children, 78/103 (75.7%) were undernourished, of whom 16/78 (20.5%) were underweight, 59/78 (75.6%) were stunted, and 3/78 (3.9%) were wasted. Household size and hospitalization frequency were associated with undernutrition (AOR = 3.8, 95% CI: 1.2–11.7, p = 0.020 and AOR = 9.2, 95% CI: 1.7–50.4, p = 0.010) respectively.

Conclusion: There is high prevalence of undernutrition among children with congenital heart disease in this study. Larger households and recurrent hospitalization were found to be associated factors of undernutrition in children with congenital heart diseases. There is a need for regular nutritional assessment and tailored nutritional education for children with CHD attending the cardiac clinics.

Mbarara Regional Referral Hospital, Mbarara, Uganda

JUNE 2024

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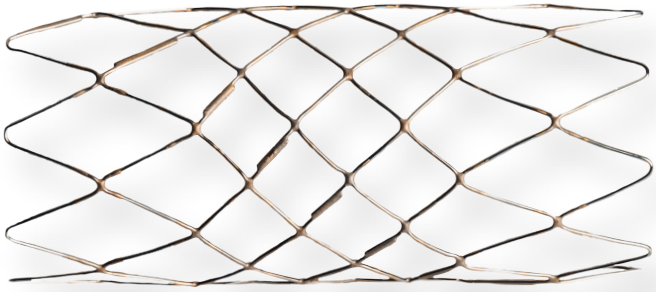

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Background

Congenital Heart Disease (CHD) is the most common congenital malformation worldwide.[1] Approximately 1.35 million newborns are diagnosed with congenital heart disease annually around the world.[2] In Africa, an estimated 500,000 children are born with CHD each year, majority in sub-Saharan Africa (SSA).[3] With increased access to health care and diagnostic imaging, there has been increased detection of congenital heart diseases globally.[4]

The biggest burden of congenital heart disease arises from developing countries, and the majority of these children receive sub-optimal or no care at all.[5] Children in SSA are affected by uncorrected Congenital Heart Diseases.[6-8] This imposes a huge burden on the health system due to limited resources and available treatment options.

Globally, 18.7 million children are undernourished.[9,10] Undernutrition remains one of the major causes of morbidity and mortality among children under five years especially in developing countries.[11] In Uganda, more than one third (38%) of children are undernourished (UBOS 2020).

Congenital Heart Disease contributes to undernutrition in children through reduced oral intake, chronic hypoxemia, higher metabolic rate, and inflammation due to cytokine malfunction, and increased energy requirements.[12] Additionally, the higher breathing rate that occurs along with congestive heart failure may contribute to increased energy requirements and failure to ingest enough food.

Undernutrition is a prevalent issue in children with CHD,[13] affecting over 60% in developing countries, leading to high morbidity and mortality rates, increased hospital stays, and increased susceptibility to infections.[14]

Undernutrition among children with Congenital Heart Disease has also been associated with frequent hospitalization, poor surgical outcomes, impaired somatic growth, and increased mortality.[3,15]

Failure to recognize undernutrition earlier and establish the associated factors or conditions has negative outcomes on treatment and prognosis, including affecting the eligibility of life-saving surgery.[16] A good nutritional assessment and management improves decision-making on different treatment modalities and improves overall well-being and outcome among children with CHD.[17]

Therefore, this study aimed to determine the prevalence and associated factors of undernutrition among children with uncorrected congenital heart disease in Uganda, focusing on pediatric cardiac clinic attendance at Mbarara Regional Referral Hospital (MRRH).

Methods

Study Design and Setting

A cross-sectional study was conducted at MRRH, the largest public hospital in Mbarara, Uganda, from March to August 2023. The hospital serves various districts and neighboring countries and is a teaching hospital for Mbarara University of Science and Technology. The pediatric cardiac clinic is the only in western Uganda.

Study Population and Eligibility Screening

The study included children aged six months to 59 months with confirmed Congenital Heart Disease, excluding those who had surgery or required urgent attention (at the point of initial contact).

Sample Size

The sample size was calculated using the formula for estimating single proportions (Kelsey, J.L., 1965). Assuming a type I error of 5%, a significance level of $p<0.05$, an absolute error or precision of 5%, and a

TOTO Ward (Children's Ward) at Mbarara Regional Referral Hospital, Mbarara, Uganda

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10% non-response rate, the minimum sample size required to replicate this analysis was 103 participants.

Sampling Procedure and Data Collection
The study recruited children with uncorrected congenital heart disease using a consecutive sampling method, obtaining informed consent from parents or caretakers. Participants were involved after receiving clinical care. A pretested questionnaire was used, and data was collected by the principal investigator and a trained research assistant. The questionnaire, clinical, and nutritional assessment using WHO 2007 Z-scores took approximately 15 minutes to complete.

Study Variables
Undernutrition was the outcome variable. The independent factors included infant/child age, sex, gestational age, birth weight, birth order, caregiver factors, medical factors, and feeding factors such as EBF, bottle feeding, and breastfeeding frequency.

Study Measures
The study analysed socio-demographics and factors associated with undernutrition in children with congenital heart disease using a questionnaire. Factors included child's age, sex, birth weight, gestational age, weaning age, and residence. Medical factors included heart failure, corrective surgery, pulmonary hypertension, and other conditions. Caregivers were asked about hospitalization frequency, clinic visits, and echocardiography reports to identify specific heart defects.

Anthropometric measurements were taken using a SECA weighing scale and a stadiometer, with heights recorded to the nearest 0.5cm. Children under two-years-old were measured lying down, while older children were measured standing. Recumbent length was converted to height if necessary. Infants and children unable to stand alone were measured by an adult, while children standing alone were measured with light clothing.

Undernutrition in children is measured using anthropometric measurements such as age, weight, height/length, and MUAC. Anthropometric z-scores are interpreted according to WHO standards, with -2SD indicating undernutrition. Heart failure severity is graded using the modified Ross score, and blood oxygen levels are assessed using a pediatric fingertip pulse oximeter P4 Plus type.

Ethical Considerations
The study received ethical approval from various committees, including the Faculty of Medicine Research Committee, Mbarara University of Science of Technology (MUST) Research Ethics Committee, and Uganda National Council for Science and Technology, and informed consent from caregivers, respecting their privacy and using a password-protected laptop for data security.

Data Analysis
The questionnaires were checked for completeness using REDCap software, and data cleaning and verification processes were implemented. Data was imported into STATA V.15 for analysis. Descriptive and analytical statistics were conducted, with normality assessed using Gaussian assumption and histograms for continuous variables. Cross-checking with child medical records or phone calls was used for missing data.

The study calculated the prevalence of undernutrition among children enrolled, calculating individual prevalence of wasting, underweight, and stunting. Analytical statistics used student t-test, Mood's median test, and Chi-square tests to assess differences between normal and undernutrition-stricken children.

We used logistic regression to model factors linked to undernutrition, focusing on factors with a p-value of less than 0.2. All factors had a VIF less than three, and the best fit model was considered using backward-forward regression, with a 95% confidence interval and p-value of 0.05.

Results
The study involved 118 children with Congenital Heart Disease. Six patients had undergone corrective surgeries, five older than five years, and four sick children requiring urgent care were excluded.

Participants' Demographic Characteristics
Children's ages ranged from six months to 59 months with a mean age of 24.2 (±15.5) months. Male (50.5%) and female (49.5%) children were almost equal, with a mean birth weight of 3.2 (±0.6) kgs and born at term with a mean gestation age of 38.3 (±1.9) weeks.

The majority of the caretakers were mothers (88.4%) residing in rural areas (57.3%) and about two-in-five had attained primary education (37.9%). We also noted that over three-fifth (60.2%) of the household had more than four people and most households (35.0%) were of low socioeconomic status, see **Table 1**.

Clinical and Nutritional Characteristics of Children with CHD
Over half of the children had acyanotic CHD (59.2%); enlarged cardiac chambers were high (64.1%), as confirmed by an echocardiogram. About three in five children (60.2%) had multiple lesions, with over half of them (54.4%) classified under ROSS class II of heart failure; close to a third (29%) had class III heart failure; and close to a fifth (17.5%) had pulmonary hypertension. The most common type of CHD among these children was a Ventriculo Septal Defect; see **Table 2** and **Figure 4**.

The majority (43.7%) were newly diagnosed patients. Many children in our study (68.9%) had been hospitalized at least three times in the past 12 months, with about half of them (48.5%) spending at least one week in-hospital each admission. Nearly a quarter of the children exhibited characteristics that could be indicative of Down Syndrome, while seven children had other features of hereditary or long-term conditions (three congenital hydrocephalus, two cleft lip, one with congenital biliary atresia, and one with Holt-Oram Syndrome traits). A number of children (66.0%) had been exclusively breastfed, with 43.7% of children weaned before six months of age. Most children had their immunization for age up-to-date (88.3%), dewormed regularly (59.2%) and regularly received vitamin A (62.1%), see **Table 2**.

Relationship Between Study Variables and Undernutrition Among Children with CHD
At inferential statistics (**Table 1, 3 and 4**), only frequency of hospitalization per year and duration of in-hospital stay during each admission showed a statistically significant difference among children who had undernutrition compared to those without.

Prevalence of Undernutrition (Wasting, Stunting and Underweight)
As shown in **Figure 1**, 78/103 (75.7%) of participants had undernutrition with over half (52.4%) of them with severe undernutrition. Over three quarters of these undernourished children were stunted 59/78 (75.6%), 16/78 (20.5%) were underweight and the minority of were wasted 3/78 (4.9%), see **Figure 2**.

The majority of the children with undernutrition had two categories of undernutrition: wasting and underweight, wasting and stunting, or underweight and stunting. In this study, 34/78 (43.6%) had more than one category of undernutrition, 17/78 (21.8%) had one category only, and 27/78 (34.6%) had symmetrical undernutrition (these children were wasted, stunted, and underweight at the same time; see **Figure 3**).

TABLE 1 Children's and Caretakers' Demographics Characteristics Among Children with Congenital Heart Disease (N = 103)
Standard deviation (SD); Interquartile range (IQR)

Participants' characteristics	n (%)	Undernutrition		X^2 (*p*–value)
		No, 25 (24.3%)	Yes, 78 (75.7%)	
Children's characteristics				
Age (in months)				
Mean ± SD	24.2 ± 15.5	25.9 ± 17.2	23.7 ± 15.0	0.62 (0.534)
Sex				
Female	51 (49.5)	15 (29.4)	36 (70.6)	1.45 (0.228)
Male	52 (50.5)	10 (19.2)	42 (80.8)	
Birth order				
Median, IQR	3, 3	3, 2	3, 3	0.13 (0.722)
Birth weight (in Kgs)				
Mean ± SD	3.2 ± 0.6	3.2 ± 0.7	3.1 ± 0.6	0.36 (0.720)
Gestational age at birth (in complete weeks)				
Mean ± SD	38.3 ± 1.9	38.2 ± 2.6	38.3 ± 1.7	–0.24 (0.810)
Caretakers' characteristics				
Caretaker's relationship				
Others	3 (2.9)	0 (0)	3 (100.0)	1.03 (0.597)
Father	9 (8.7)	2 (22.2)	7 (77.8)	
Mother	91 (88.4)	23 (25.3)	68 (74.7)	
Place of residence				
Urban	44 (42.7)	11 (25.0)	33 (75.0)	0.02 (0.882)
Rural	59 (57.3)	14 (23.7)	45 (76.3)	
Occupation				
Employed	28 (27.2)	10 (35.7)	18 (64.3)	3.18 (0.204)
Housewife	29 (28.2)	7 (24.1)	22 (75.9)	
Others	46 (44.7)	8 (17.4)	38 (82.6)	
Household size				
≤ 4 people	41 (39.8)	14 (34.2)	27 (65.8)	3.61 (0.057)
> 4 people	62 (60.2)	11 (17.7)	51 (82.3)	
Level of education				
None	13 (12.6)	6 (46.2)	7 (53.8)	7.23 (0.065)
Primary	39 (37.9)	6 (15.4)	33 (84.6)	
Secondary	32 (31.1)	6 (18.8)	26 (81.2)	
Tertiary	19 (18.4)	7 (36.8)	12 (63.2)	
Socioeconomic status				
Low	36 (35.0)	6 (16.7)	30 (83.3)	3.55 (0.170)
Middle	33 (32.0)	7 (21.2)	26 (78.8)	
High	34 (33.0)	12 (35.3)	22 (64.7)	

TABLE 2 Clinical and Nutritional Factors Among Children with Congenital Heart Disease
Echocardiogram (ECHO); Oxygen saturation (SPO2)

Characteristics	n (%)	Undernutrition		*p* – value
		No, 25 (24.3%)	Yes, 78 (75.7%)	
Clinical characteristics				
Type of CHD				
Cyanotic CHD	42 (40.8)	13 (30.9)	29 (69.1)	1.72 (0.189)
Acyanotic CHD	61 (59.2)	12 (19.7)	49 (80.3)	
Cardiac chamber enlargement by ECHO				
No	37 (35.9)	9 (24.3)	28 (75.7)	0.01(0.993)
Yes	66 (64.1)	16 (24.2)	50 (75.8)	
ROSS class of Heart failure				
Class I	18 (17.5)	6 (33.3)	12 (66.7)	2.73 (0.255)
Class II	56 (54.4)	15 (26.8)	41 (73.2)	
Class III	29 (28.2)	4 (13.8)	25 (86.2)	
Number of Congenital Heart Disease				
Single CHD	41 (39.8)	11 (26.8)	30 (73.2)	0.24 (0.623)
Multiple CHD	62 (60.2)	14 (22.6)	48 (77.4)	
Frequency of follow up				
New patient	45 (43.7)	13 (28.9)	32 (71.1)	1.46 (0.481)
Every 2 months	38 (36.9)	9 (23.7)	29 (76.3)	
Every 3 months or more	20 (19.4)	3 (15.0)	17 (85.0)	
With pulmonary hypertension				
No	85 (82.5)	21 (24.7)	64 (75.3)	0.05 (0.823)
Yes	18 (17.5)	4 (22.2)	14 (77.8)	

TABLE 2 Continued

Duration of symptoms before diagnosis of CHD				
< 6 months	61 (59.2)	13 (21.3)	48 (78.7)	0.71 (0.398)
≥ 6 months	42 (40.8)	12 (28.6)	30 (71.4)	
Hospitalization frequency per year				
Never	13 (12.6)	7 (53.9)	6 (46.1)	7.60 (**0.022**)
≤ 3 times	71 (68.9)	13 (18.3)	58 (81.7)	
> 3 times	19 (18.5)	5 (26.3)	14 (73.7)	
In–patient hospital stays per each admission				
Never	13 (12.6)	7 (53.8)	6 (46.2)	7.32 (**0.026**)
≤ 1 week	50 (48.5)	11 (22.0)	39 (78.0)	
> 1 week	40 (38.8)	7 (17.5)	33 (82.5)	
SpO_2 levels				
Normal > 90%	35 (34.0)	7 (20.0)	28 (80.0)	0.53 (0.468)
Low ≤ 90%	68 (66.0)	18 (26.5)	50 (73.5)	
Genetic dysmorphism & chronic illness				
None	72 (69.9)	20 (27.8)	52 (72.2)	5.11 (0.078)
Down syndrome	24 (23.3)	2 (8.3)	22 (91.7)	
Others	7 (6.8)	3 (42.9)	4 (57.1)	
Age of diagnosis of CHD				
Before 6 months of age	36 (34.9)	7 (19.4)	29 (80.6)	0.70 (0.402)
After 6 months of age	67 (65.1)	18 (26.9)	49 (73.1)	
Nutritional Factors				
Exclusive breast feeding for 6 months				
No	35 (34.0)	6 (17.1)	29 (82.9)	1.46 (0.226)
Yes	68 (66.0)	19 (27.9)	49 (72.1)	
History of bottle feeding				
No	78 (75.7)	17 (21.8)	61 (78.2)	1.07 (0.300)
Yes	25 (24.3)	8 (32.0)	17 (68.0)	
Frequency of breast feeding per day				
Less than 8 times	35 (34.0)	9 (25.7)	26 (74.3)	0.06 (0.806)
8 times or more	68 (66.0)	16 (23.5)	52 (76.5)	
Age at weaning				
Less than 6 months	45 (43.7)	8 (17.8)	37 (82.2)	1.83 (0.176)
6 months or more	58 (56.3)	17 (29.3)	41 (70.7)	
Immunization status				
Missed	12 (11.7)	5 (41.7)	7 (58.3)	2.24 (0.135)
Up to date	91 (88.3)	20 (22.0)	71 (78.0)	
Deworming				
Never dewormed	10 (9.7)	1 (10.0)	9 (90.0)	1.24 (0.537)
Irregularly	32 (31.1)	8 (25.0)	24 (75.0)	
Regularly 6 monthly	61 (59.2)	16 (26.2)	45 (73.8)	
Vitamin A administration				
Irregularly	39 (37.9)	10 (25.6)	29 (74.4)	0.06 (0.800)
Regular	64 (62.1)	15 (23.4)	49 (76.6)	

TABLE 3 Factors Associated with Undernutrition
Crude odds ratio (cOR); Adjusted odds ratio (aOR); Confidence interval (CI)

Characteristics	Bivariate analysis		Multivariate analysis	
	Crude OR (95% CI)	*p* – value	Adjusted OR (95% CI)	*p* – value
Caretaker's demographics				
Household size				
≤ 4 people	1		1	
> 4 people	2.4 (0.9 – 6.0)	0.061	3.8 (1.2 – 11.7)	0.020
Level of education				
None	1		1	
Primary	4.7 (1.2 – 19.0)	0.029	3.5 (0.7 – 17.1)	0.120
Secondary	3.7 (0.9 – 15.2)	0.067	4.3 (0.8 – 22.8)	0.085
Tertiary	1.5 (0.3 – 6.2)	0.599	0.8 (0.1 – 5.5)	0.857
Socioeconomic status				
Low	1		1	
Middle	0.7 (0.2 – 2.5)	0.630	0.9 (0.2 – 4.1)	0.847
High	0.4 (0.1 – 1.1)	0.080	0.4 (0.1 – 1.8)	

TABLE 4 Clinical Characteristics as Predictors of Undernutrition in Children with CHD

Study Variable	Frequency (%)	Unadjusted OR	p - value	Adjusted OR	p - value
Hospitalization frequency per year					
Never	13 (12.6)	1		1	
≤ 3 times	71 (68.9)	5.2 (1.5 – 18.1)	0.009	9.2 (1.7 – 50.4)	0.010
> 3 times	19 (18.5)	3.3 (0.7 – 14.5)	0.120	2.4 (0.4 – 13.6)	0.312
In–patient hospital stays per each admission					
Never	13 (12.6)	1		1	
≤ 1 week	50 (48.5)	4.1 (1.2 – 14.9)	0.030	0.6 (0.2 – 2.3)	0.483
> 1 week	40 (38.8)	5.5 (1.4 – 21.5)	0.014	Omitted	0.420

FIGURE 1 Nutrition Status Among the Children with Congenital Heart Disease

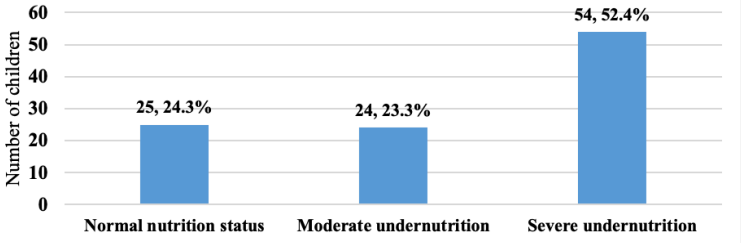


FIGURE 2 Proportion of Children with Wasting, Underweight and Stunting Among the Undernourished

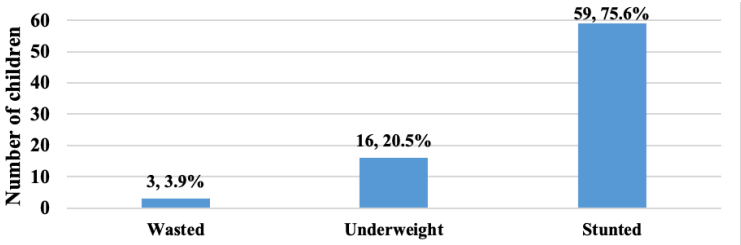


FIGURE 3 Number of Undernutrition Categories

Single: Either wasting, stunting or underweight
Double: Wasting and underweight, wasting and stunting, or underweight and stunting
Symmetric: Wasted, stunted, and underweight in one patient.

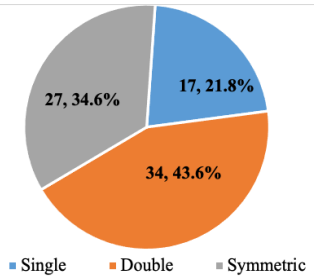
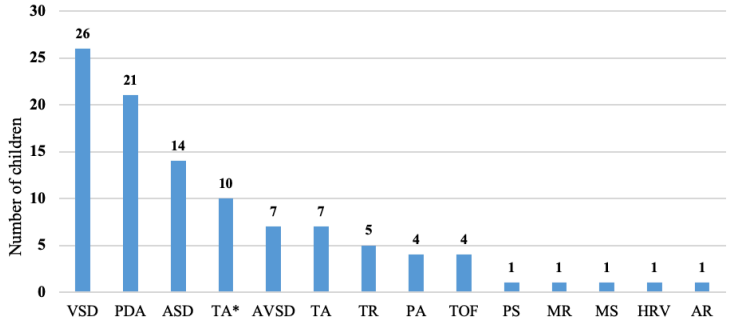


FIGURE 4 Types of Specific Congenital Heart Disease

Legend: Ventriculoseptal defect (VSD); Patent ductus arteriosus (PDA); Atrioseptal defect (ASD); Tricuspid atresia (TA); Atrioventricular septal defect (AVSD); Truncus arteriosus (TA); Tricuspid regurgitation (TR); Pulmonary atresia (PA); Tetralogy of Fallot (TOF); Pulmonary stenosis (PS); Mitral regurgitation (MR); Mitral stenosis (MS); Hypoplastic right ventricle (HRV); Aortic regurgitation (AR)*



Factors Associated with Undernutrition Among Children with CHD

Caretaker's primary level of education (cOR = 4.7, 95% CI: 1.2 – 19.0, p =0.029), hospitalization frequency per year of ≤ 3 times (cOR = 5.2, 95% CI: 1.5 – 18.1, p = 0.009), in-patient hospital stays per each admission of ≤ 1 week (cOR = 4.1, 95% CI: 1.2 – 14.9, p = 0.030) and > 1 week in-hospital stay (cOR = 5.5, 95% CI: 1.4 – 21.5, p = 0.014) increased the odds of undernutrition at bivariate analysis (Table 3). However, at multivariate analysis, after controlling the infant, caretaker, feeding and medical factors. Household size (aOR = 3.8, 95% CI: 1.2 – 11.7, p = 0.020) and hospitalization frequency of at least three times in a year (aOR = 9.2, 95% CI: 1.7 – 50.4, p = 0.010) increased the odds of undernutrition in the adjusted model (**Table 4**).

Discussion

This study investigated the prevalence of undernutrition (including wasting, stunting and underweight) among children six to 59 months with Congenital Heart Disease and assessed the factors associated with undernutrition at Mbarara Regional Referral Hospital in Mbarara, southwestern Uganda. There was high prevalence of undernutrition among children with CHD in this study (75.7%). Larger households and recurrent hospitalization were found to be associated factors.

Prevalence of undernutrition among children with CHD

The overall prevalence of undernutrition in children with CHD was 75.7%, which is high, with 52.4% of these children having severe undernutrition and 23.3% having moderate undernutrition.

We found a high proportion of undernutrition in children with CHD compared to other studies that have been done in Ethiopia (49.9%), Uganda (39.8%), Turkey (55.3%), Iran (16.9%), and India (59.0%).[18-22]

Our study's significant prevalence of undernutrition may be explained by the fact that nearly half of the children with CHD presented later than expected (after six months) and, as a result, were not receiving treatment and did not undergo corrective cardiac surgery. Additionally, we only evaluated young children under the age of five who were already at risk for undernutrition even in the absence of a congenital heart abnormality. The other studies mentioned above assessed children up to 18-years-old; most of them were already on treatment, and some of them received corrective cardiac surgeries. These factors may contribute to the high prevalence of undernutrition.

The prevalence of stunting, an indicator of chronic undernutrition, was found to be 75.67%, and that of wasting, which is an indicator of acute undernutrition, was 3.9%, whereas the prevalence of underweight was found to be 20.5%. This is three times higher than the local (Uganda) prevalence of stunting in children under five.[23] This may be explained by the fact that children with CHD have a chronic heart condition that makes them more susceptible to undernutrition.

We found higher prevalence of stunting in children with CHD compared to most of the studies done in Africa and Asia. The difference might be explained by the fact that these studies[18-22] did not assess other factors that are known to contribute to undernutrition in these children with Congenital Heart Diseases, such as genetic disorders, birth anomalies, and the social and economic status of the households. In addition, regardless of age or whether they had corrective surgery or not, some of these studies included all children with CHD, in contrast to our study, which included only children who were under five and had not undergone cardiac corrective surgery. Children with acute and long-term illnesses (e.g. HIV, cleft lip or plate, cerebral palsy, etc.) other than congenital heart conditions were also excluded in the above studies.

Furthermore, a double category of undernutrition affected 43.6% of the undernourished children, symmetrical undernutrition (wasting, stunting, and underweight) category affected 34.6%, and a single category of

undernutrition affected 21.8% of the undernourished children with CHD.

Similar to our findings, a higher prevalence of undernutrition in children with Congenital Heart Disease has also been documented in several studies with most of them having severe undernutrition. For instance, rates of 90.4%, 84.0 % and 67.9% have been reported in Nigeria,[24] Egypt,[25] and Indonesia,[26] respectively. These findings could be explained by the same selection criteria of under-fives with no corrective cardiac surgeries, the presence of severe complications of CHD such as congestive heart failure and not on medications, and a late diagnosis of CHD.

The prevalence of underweight in this study was 20.65%, which is similar to studies done by Okoromah and Hassan in Nigeria (20.5%)[24] and Egypt (24.3%).[25] The similarities could be explained by the fact that the studies have been done in the same demographic area with the same risk factors for undernutrition among these children.

In our study, children with Congenital Heart Disease had a higher prevalence of stunting (75.6%), which is chronic undernutrition, than in studies conducted in Africa (Nigeria, Egypt, and Uganda)[25] or Asia (India and Turkey).[21] This could be due to a number of factors, such as limited access to healthcare services, which causes communities to first turn to traditional remedies and delays the diagnosis and treatment of complications and comorbidities.

Cultural beliefs and practices related to infant and child care, feeding practices, and healthcare-seeking behavior can influence the nutritional status of children with congenital diseases.[27,28] Furthermore, the prevalence of wasting in this study was 3.9%, which is much lower than the studies done in Ethiopia, Nigeria, Egypt, and India. This variation might be because these studies done on children who are admitted to the hospital compared to our study, which was done on out-patients. It is expected that children on OPD follow up to be healthier than those who are admitted and critically ill. Children admitted to hospitals are more likely to have severe illnesses, complications, and comorbidities that may predispose to wasting.[29] This could explain the higher prevalence of wasting compared to other studies.

This study highlighted an important observation regarding the prevalence of undernutrition in children with Congenital Heart Disease. Indeed, while the overall trend of high undernutrition prevalence among these children is consistent, the specific factors contributing to malnutrition can vary based on a multitude of influences.

Factors Associated with Undernutrition Among Children with CHD

Frequent hospitalization was associated with a nine-fold increase in being undernourished in children with CHD. Repeated hospital stays can interfere with the child's typical nutritional intake and feeding habits due to medical treatments or procedures like frequent I.V. cannulations and catheterizations. Hospitalized children with CHD may experience decreased appetite, difficulties feeding, or dietary restrictions. This decrease in dietary intake across several hospital visits may be a factor in undernutrition.

In addition, children with CHD who need frequent hospital stays probably have more serious and complicated medical issues.[30] Undernutrition can be exacerbated by severe sickness, which can also cause changes in nutritional absorption, increased energy expenditure, and decreased appetite.[31]

Frequent hospitalizations in CHD are associated with heart failure which induces physiological stress.[32] This stress response can affect metabolism, increase nutrient requirements, and lead to the breakdown of muscle tissue, contributing to undernutrition. Frequent hospitalizations expose children to a higher risk of infections, which can increase inflammation in the body.[33] Chronic inflammation can lead to appetite suppression, altered nutrient utilization, and muscle wasting, all of which contribute to undernutrition.[31]

Similar to this study, studies done by Mulat et al. and Okoromah et al. in Ethiopia and Nigeria, respectively, also reported recurrent hospitalization to be associated with undernutrition in children with CHD.[24,34] This similarity can be defined by the same geographic (Africa) location, being a regional referral hospital and a three-quarter of the children were from low socioeconomic status, and did not have adequate access to a specialized healthcare, including surgical and medical interventions for CHD. This could lead to delayed or inadequate treatment, resulting in recurrent hospitalizations and subsequent undernutrition.

We also found an almost four-fold increase of undernutrition in children with CHD whose household size was more than four people in total. In households with more members, there might be increased competition for available food. Children with CHD might not receive adequate portions or nutritious foods, resulting in undernutrition. In addition to that, larger households might have higher caregiving demands, potentially affecting the ability of caregivers to focus on the specific needs of a child with CHD, including ensuring proper nutrition. In households with more members, there might be increased challenges in accessing healthcare facilities and services, leading to delays in seeking medical attention for children with CHD and subsequent undernutrition. This has also been found in other studies conducted in Africa, Bangaledsh and India.[20,25,35]

Strengths and Limitations

The study looked at undernutrition in children under five-years-old with Congenital Heart Disease who have not undergone corrective surgeries. It also examined children who were not hospitalized but who were at home, providing a better understanding of their nutritional status. In addition to that, it also considered comorbidities like genetic disorders and social and economic status, which also contributed to its strength. However, limitations include not assessing micronutrient deficiencies, not using specific charts for measuring undernutrition in Down Syndrome and using a cross-sectional design.

Conclusion Recommendations

The study found a high prevalence of wasting, underweight, and stunting in children with Congenital Heart Disease, linked to factors like household size and hospitalization frequency. Recommendations include regular nutritional assessments, specific education, family planning counseling, and timely intervention for corrective surgery.

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Author's Contribution

IYH conceived and designed the study; IYH and ND led the data collection effort. IYH and ND interpreted the data and drafted the first version of the manuscript. All authors approved the final manuscript for publication.

Ethical Approval and Consent to Participate

The study was approved by Mbarara University of Science and Technology Research Ethics Committee (#MUST-2022-734) and all participants provided consent prior to participation in the study. All the participants' information were anonymously presented in this study.

Availability of Data and Materials

The datasets will be made available to appropriate academic parties on request from the corresponding author.

Conflicts of Interest

None

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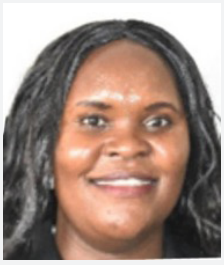

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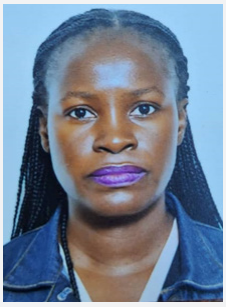

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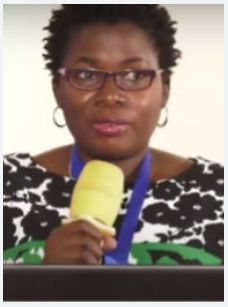

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Lexeo Therapeutics Granted FDA Fast Track Designation for LX2006, an AAV-Based Gene Therapy Candidate for the Treatment of Friedreich's Ataxia Cardiomyopathy

NEW YORK (GLOBE NEWSWIRE) -- Lexeo Therapeutics, Inc. (Nasdaq: LXEO), a clinical stage genetic medicine company dedicated to pioneering treatments for genetically defined cardiovascular diseases and APOE4-associated Alzheimer's disease, today announced the U.S. Food and Drug Administration (FDA) has granted Fast Track designation to LX2006, the company's AAVrh.10hFXN-based gene therapy candidate for the treatment of Friedreich's ataxia (FA) cardiomyopathy. LX2006 is designed to deliver a functional frataxin gene to promote frataxin protein expression and restore mitochondrial function in myocardial cells.

Fast Track is a process designed to facilitate the development and expedite the review of new drugs intended to treat serious conditions and address unmet medical need. This designation was granted based on available preclinical data. SUNRISE-FA, a Phase 1/2 multicenter, 52-week, dose-ascending, open-label clinical trial, is ongoing to evaluate the safety and tolerability, as well as preliminary efficacy, of LX2006 in patients with FA cardiomyopathy.

"FA cardiomyopathy is the leading cause of death among FA patients, and there are currently no approved treatment options. The FDA's Fast Track designation for LX2006 underscores the significant unmet need for effective treatment options to address the cardiac impact of this debilitating disease," said R. Nolan Townsend, Chief Executive Officer of Lexeo Therapeutics. "We believe today's Fast Track designation, along with the previously announced Rare Pediatric Disease and Orphan Drug designations granted to LX2006, will allow for enhanced regulatory interactions and the potential for this life-improving therapy to reach FA patients more quickly."

LX2006 is administered as a one-time intravenous infusion to patients in at least two ascending-dose cohorts with the potential for a third cohort. Long-term safety and efficacy will be evaluated for an additional four years following completion of the initial year of the trial, resulting in data from a total of five years post-LX2006 treatment.

About LX2006

LX2006 is an AAV-based gene therapy candidate delivered intravenously for the treatment of FA cardiomyopathy, the most common cause of mortality in patients with FA affecting approximately 5,000 patients in the United States. LX2006 is designed to target the cardiac manifestations of FA by delivering a functional frataxin gene to promote the expression of the frataxin protein and restore mitochondrial function in myocardial cells. In preclinical studies, LX2006 reversed the cardiac abnormalities in FA disease models and showed improvement in cardiac function and survival while demonstrating a favorable safety profile. The FDA has granted Fast Track designation, Rare Pediatric Disease designation and Orphan Drug designation to LX2006 for the treatment of FA cardiomyopathy.

About Lexeo Therapeutics

Lexeo Therapeutics is a New York City-based, clinical stage genetic medicine company dedicated to transforming healthcare by applying pioneering science to fundamentally change how genetically defined cardiovascular diseases and APOE4-associated Alzheimer's disease are treated. Using a stepwise development approach, Lexeo is leveraging early proof-of-concept functional and biomarker data to advance a pipeline of cardiovascular and APOE4-associated Alzheimer's disease programs.

Cautionary Note Regarding Forward-Looking Statements

Certain statements in this press release may constitute "forward-looking statements" within the meaning of the federal securities laws, including, but not limited to, our expectations and plans regarding our current product candidates and programs, including statements regarding the anticipated timing of the initiation of and results from our clinical trials and other information that is not historical information. Words such as "may," "might," "will," "objective," "intend," "should," "could," "can," "would," "expect," "believe," "design," "estimate," "predict," "potential," "develop," "plan" or the negative of these terms, and similar expressions, or statements regarding intent, belief, or current expectations, are forward-looking statements. While Lexeo believes these forward-looking statements are reasonable, undue reliance should not be placed on any such forward-looking statements. These forward-looking statements are based upon current information available to the company as well as certain estimates and assumptions and are subject to various risks and uncertainties (including, without limitation, those set forth in Lexeo's filings with the U.S. Securities and Exchange Commission (SEC)), many of which are beyond the company's control and subject to change. Actual results could be materially different from those indicated by such forward looking statements as a result of many factors, including but not limited to: risks and uncertainties related to global macroeconomic conditions and related volatility; expectations regarding the initiation, progress, and expected results of Lexeo's preclinical studies, clinical trials and research and development programs; the unpredictable relationship between preclinical study results and clinical study results; delays in submission of regulatory filings or failure to receive regulatory approval; liquidity and capital resources; and other risks and uncertainties identified in Lexeo's Annual Report on Form 10-K for the annual period ended December 31, 2023, filed with the SEC on March 11, 2024, and subsequent future filings Lexeo may make with the SEC. New risks and uncertainties may emerge from time to time, and it is not possible to predict all risks and uncertainties. Lexeo claims the protection of the Safe Harbor contained in the Private Securities Litigation Reform Act of 1995 for forward-looking statements. Lexeo expressly disclaims any obligation to update or alter any statements whether as a result of new information, future events or otherwise, except as required by law.

Dobson Family Gift to Driscoll Marks New Era for Nationally Recognized Heart Program

Multimillion dollar gift expands pediatric cardiac care in South Texas

Corpus Christi, Texas (GLOBE NEWSWIRE) -- Driscoll Children's Hospital is celebrating a multimillion dollar gift by the Dobson Family Foundations, Las Aguilas Enterprises, and individual Dobson family members to support its Heart Center, a nationally recognized pediatric cardiac program that treats children and newborns with the most complex congenital heart diseases.

Funds from the gift will be used to complete the construction of the Heart Center's new procedural suite, a facility that includes two operating rooms, two cardiac catheterization laboratories with a 10-bed cardiac intensive care unit all housed on the fourth floor of the Pavilion building at Driscoll Children's Hospital. An additional new 25-bed cardiac intensive care unit will be housed on the third floor of the Driscoll Pavilion. Furthermore, the historic gift will establish the Harmon and Grace Dobson Distinguished Chair in Cardiac Surgery, the first of its kind at Driscoll and in South Texas. Chief of Pediatric Cardiac Surgery Dr. Stephen Langley, who began leading the heart program in 2019, will be the first recipient of the prestigious title.

"It's difficult to express our gratitude in words. The Heart Center is growing faster than anyone could have anticipated and most importantly we are achieving outstanding results. This donation will usher in a new era for pediatric cardiac care in South Texas," said Dr. Langley.

The Heart Center at Driscoll Children's Hospital offers families access to a wide range of heart specialties, **https://driscollchildrens.org/heart-center/**, and services, including pediatric cardiology, pediatric cardiac surgery, pediatric cardiac anesthesia, pediatric cardiac intensive care, pediatric electrophysiology, cardiac catheterization, cardiac cross sectional imaging, fetal imaging and other cutting-edge medical services and technologies. The new Heart Center Procedural Suite will further advance our specialty care for our patients as well as support our growth and expanded services.

According to data collected, analyzed and publicly reported by the Society of Thoracic Surgeons, **https://driscollchildrens.org/heart-center/**, the Heart Center at Driscoll Children's Hospital has one of the lowest mortalities nationally for pediatric cardiac surgery. Furthermore, survival at the Driscoll Heart Center for the highest risk patients is one of the best in the United States.

"This is the largest gift solely devoted to heart care in Driscoll's history. In honor of the Dobson family's everlasting gift, the fourth floor of the Pavilion will be named the Dobson Family Cardiac Suite. Driscoll is grateful to the Dobson family for their faith in and commitment to our mission," said Driscoll President and CEO Eric Hamon.

"Driscoll's heart program is inspiring. The family is honored to be a part of a program that cares for the smallest hearts of South Texas," said Heather Dobson, president of Tres Grace Family Foundation.

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