# Malnutrition in children with Congenital Heart Disease in Low and Middle income countries.

### Supplementary Table 1

| **Authors** | **Year** | **Patient group** | **Conclusions** |
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| **Evidence of inadequate intake** |
| Krieger and Chen [1](#_ENREF_1) | 1969 | 7 children with CHD  | No difference between the basal metabolic rate of these children and normal controls |
| Menon et al[3](#_ENREF_3) | 1985 | 21 infants with CHD and 9 control infants | Failure to thrive in infants with CHD may be due to a combination of low energy intakes and, in some cases, high energy requirements allowing insufficient energy for normal growth |
| Yahav et al [4](#_ENREF_4) | 1985 | 14 infants with CHD and failure to thrive | Assessment of intestinal function revealed minor absorptive abnormalities, (mild steatorrhea in three patients, bile salt loss in four patients), delayed gastric emptying, and abnormal triglyceride loading tests; low caloric intake (88.3 +/- 19.3 kcal/kg/day) appeared to be the main reason for failure to gain weight |
| Salzer et al [5](#_ENREF_5) | 1989 | 8 infants with cyanotic heart disease and 8 with isolated left-to-right shunts | Normal serum prealbumin and albumin in the infants with CHD ruled out protein-calorie malnutrition; a low level of food intake was not the main cause of inadequate growth and of small subcutaneous fat stores in these two small, but homogeneous, groups of infants with CHD |
| Thommessen et al[6](#_ENREF_6) | 1992 | 40 children (0.9-13 years) with CHD | At the time of study, refusal to eat or poor appetite was reported as a significant problem in 19 children and subnormal height and/or weight were recorded in 11 children. The children ate considerably less calories than recommended for healthy children.  |
| Hansen & Dorup[7](#_ENREF_7" \o "Hansen, 1993 #1493) | 1993 | 22 children with CHD (mean age 39 months, range 12-126 months), prior to corrective operation | Energy intake was less than recommended by the FAO/WHO/UNU, while protein intake was generally high, and even sufficient to allow catch-up growth |
| Barton et al [8](#_ENREF_8) | 1994 | 8 infants with severe CHD | Total daily energy expenditure was greater than in normal controls, while the energy intake was only 82% of expected |
| Mitchell et al [9](#_ENREF_9) | 1994 | 18 children with CHD | In 5 patients metabolic rates were clearly elevated prior to surgery |
| Unger et al, [10](#_ENREF_10) | 1992 | 19 underweight patients with CHD and 16 normal-weight patients with CHD, aged 1 month to 2 years | Nutritional evaluation of patients with CHD demonstrated that underweight children had inadequate diets |
|  |  |  |  |
| **Evidence of response to increased nutritional intake** |
| Vanderhoof et al[11](#_ENREF_11) | 1982 | 11 children with growth failure and CHD | All children gained weight with the institution of continuous enteral feeds |
| Bougie et al [12](#_ENREF_12) | 1986 | 13 patients with CHD | 12 of 13 given continuous enteral nutrition displayed normal growth |
| Schwarz et al [13](#_ENREF_13) | 1990 | 19 infants with cardiac anomalies who were not candidates for early corrective surgery | Infants with CHD complicated by malnutrition manifest increased nutrient requirements for growth and weight gain; continuous, 24-hour, nasogastric alimentation is a safe and effective method for achieving both increased nutrient intake and improved overall nutritional status in these infants |
| Jackson & Poskitt[14](#_ENREF_14" \o "Jackson, 1991 #1573) | 1991 | Infants with CHD | Recommended that infants with CHD known to be associated with failure to thrive are fed on high-energy diets from the time of diagnosis in order to optimize growth |
| Hehir et al [15](#_ENREF_15) | 2016 | Mostly infants with single ventricle cardiac anatomy (in the richer countries) | Improved growth and outcomes when feeding protocols are implemented |
|  |  |  |  |
| **Miconutrient deficiency** |
| Steier et al[16](#_ENREF_16) | 1976 | 31 children with heart disease (27 with CHD) | Riboflavin deficiency present in 11 children (all with CHD); greater tendency to have riboflavin deficiency in those with congestive heart failure |

### Supplementary Table 2: Reports on Nutritional status of children with CHD in LMICs

| **Authors** | **Year** | **Country** | **Population** | **Comments** |
| --- | --- | --- | --- | --- |
| Leite et al,  | 1995 | Brazil | 30 children with CHD and left-to-right shunt (16 with and 14 without pulmonary hypertension)  | Waterlow's criteria showed an overall prevalence of malnutrition of 83.3%, which was higher in those with pulmonary hypertension (p = 0.0140)  |
| Leite et al, [17](#_ENREF_17) | 1995 | Brazil | 50 children undergoing cardiac surgery and classified in high and low surgical risk, prospectively evaluated | 78% were malnourished by anthropometric features; the percentage of weight per height, serum albumin and transferrin did not help to prognosticate postoperative morbidity  |
| Thompson Chagoyan et al, [18](#_ENREF_18) | 1998 | Mexico | 66 children with CHD | 50 children were malnourished, (26 compensated, 23 non-compensated and one acute); 16 were normal; 85% of the children presented with diminished muscular area and 97% with diminished body fat |
| Varan et al, [19](#_ENREF_19) | 1999 | Turkey | 89 patients with CHD aged 1-45 months. | 37 of the 89 patients were in the < 5th percentile for both weight and length; 58 were in the < 5th percentile for weight |
| Venugopalan et al, [20](#_ENREF_20) | 2001 | Oman | 152 children with CHD (of whom 73 were symptomatic), and 152 children with innocent cardiac murmurs from 1997 to 1998 | 27% and 24% of children with CHD had “acute malnutrition”, (weight <3rd percentile for age and height >3rd percentile), and chronic malnutrition (weight and height <3rd percentile for age) respectively; symptomatic children with CHD had a reduction in weight (p<0.01), height (p=0.02) and head circumference (p<0.01) compared to controls |
| Villasis-Keever [21](#_ENREF_21) | 2001 | Mexico | 244 children (<17 years) at a single hospital in Mexico City | 40.9%, 24.6% and 31.1% had a Z-score of <-2 for weight for age, height for age and weight for height indices respectively; indices were worst in the group with pulmonary hypertension |
| Vaidyanathan et al, [22](#_ENREF_22) | 2006 | India | 100 consecutive infants (age at surgery: 7.2 +/- 3.2 months) followed prospectively from time of VSD closure at a referral center in southern India | At surgery, 44% and 30% of patients had weight and height Z score <-3, respectively |
| Da Silva et al, [23](#_ENREF_23) | 2007 | Brasil | 135 children 1 year or younger, with CHD who had not undergone surgical correction | Nutritional defects were more evident in weight-for-age; boys had worse deficiencies in weight-for-age; girls had worse values for height-for-age |
| Vieira et al, [24](#_ENREF_24) | 2007 | Brasil | Children between 0 and 24 months of age with CHD | Daily intake of calories, fats, fiber, potassium and iron were below the recommended levels (p < 0.05); intake of proteins per kilogram, carbohydrates, calcium and vitamin C were above recommended levels (p < 0.05) |
| Vaidyanathan et al[25](#_ENREF_25) | 2009 | India | 476 patients undergoing corrective intervention (surgical: 344; catheter-based: 132) | Z scores of less than -2 for weight-for-age, height-for-age, and weight/height were recorded in 59%, 26.3%, and 55.9% of patients, respectively, at presentation |
| Tokel et al, [26](#_ENREF_26) | 2010 | Turkey | 60 infants who underwent corrective surgery for CHD | At presentation, 51 patients (85%) had malnutrition; the worst parameters were seen in children with significant left to right shunts and children with pulmonary hypertension |
| Dalili et al, [27](#_ENREF_27) | 2011 | Iran | 469 patients with significant CHD aged from 1 month to 18 years | In all patients, body weight and height were significantly lower than in the normal population; this difference was greatest in the weight measures of female children; The risk factors for growth failure were large left-to-right intracardiac shunts, pulmonary hypertension and cyanosis |
| Kasar et al, [28](#_ENREF_28) | 2011 | India | Cohort of 100 economically disadvantaged children followed up after cardiac surgery for nutritional recovery | 61% of children were regarded as malnourished prior to surgery, and 27% were found to be malnourished after surgery (median of 48 months later, range 9-60 months) |
| Okoromah et al, [29](#_ENREF_29) | 2011 | Nigeria | Children aged 3-192 months with uncorrected symptomatic CHD at a tertiary hospital in Lagos Nigeria, March 2006 to March 2008, (with matched controls) | 90.4% of cases and 21.1% of controls had malnutrition (p=0.0001), and 61.2% and 2.6%, respectively, had severe malnutrition (p=0.0001); wasting, stunting and underweight were identified in 41.1%, 28.8% and 20.5% respectively in children with CHD; wasting was significantly higher (58.3%) in acyanotic CHD (p=0.0001), and stunting (68.0%) in cyanotic CHD (p=0.0001) |
| Ratanachu-Ek et al, [30](#_ENREF_30) | 2011 | Thailand | 71 patients with CHD enrolled in a prospective, 2-center cohort study | Nutritional status before surgery was defined as normal in 57%, malnutrition in 40% and over-nutrition in 3%; “Malnutrition” included underweight (28%), wasting (22%) and stunting (16%) |
| Laura Gabriela et al, [31](#_ENREF_31) | 2012 | Brasil | 75 children, aged 0-6 years, with CHD at a single cardiac clinic  | Children with CHD had higher evidence of poor growth, and lower bone density than normal controls |
| Soliman et al, [33](#_ENREF_33) | 2012 | Qatar | 27 infants and children with congenital acyanotic heart disease with left to right shunt (10 with VSD, 8 with ASD, 9 PDA) without heart failure, or severe pulmonary hypertension, before and 12 months or more after surgical or catheter intervention | Before surgery children were significantly shorter, with lower BMI compared to normal controls. 12 months after surgery there was a significant increase in the BMI and height.  |
| Radman et al, [34](#_ENREF_34) | 2014 | Guatamala | 71 patients with CHD were enrolled in a prospective, 2-center (Guatamala City in Guatamala and San Francisico in the USA) cohort study to determine the association between preoperative nutritional status and postoperative outcomes following surgery for CHD | Lower total body fat mass and acute and chronic malnourishment were associated with worse clinical outcomes in children undergoing surgery for CHD in the USA, but this was not statistically significant in Guatamala. |
| Arodiwe et al, [35](#_ENREF_35) | 2015 | Nigeria | 50 children with CHD in an outpatient setting of a hospital in Nigeria | 46 (92%) were found to be malnourished; malnutrition was related to age in years, age appropriate dietary adequacy and pulmonary hypertension  |
| Hassan et al,[36](#_ENREF_36)  | 2015 | Egypt | Case-control study of 100 children with symptomatic CHD (76 acyanotic and 24 cyanotic), and 100 healthy children matched for age and sex as a control group | Malnutrition was defined as weight, height, and weight/height Z score </=-2; overall prevalence of malnutrition was 84.0% in patients with CHD and 20% in controls |
| Batte et al, [37](#_ENREF_37) | 2017 | Uganda | Cross-sectional study among 194 children aged 0-15 years attending Mulago Hospital with CHD; conducted between August 2013 and March 2014 | 31.5% children aged 0-5 years were wasted; 42.5% aged 0-10 years were underweight; 45.4% children were stunted; and 27.3% were thin (BMI for age z score < -2). |

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