Ellisras Longitudinal Study 2017: Childhood underweight and blood pressure status in a rural black population of South Africa (ELS 26)

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Abstract

**Aim:** Childhood underweight is a problem being faced by rural black South African populations but little is known about its risk factors. The aim of this study was to investigate the risk factors related to childhood underweight in rural black South African children within the area known as Ellisras.

**Methods:** A cross-sectional study was conducted as part of the ongoing Ellisras Longitudinal Study. The current study comprised a total of 1 811 pre-primary and primary school children (934 males and 877 females) aged between five and 16 years. The chi-squared automatic interaction detection (CHAID) decision tree model was used to identify factors and determine their relationships with childhood underweight.

**Results:** A total of 1 811 children were involved in the study, of whom about 81% were severely underweight. The CHAID model showed that the variables: nutrition, age group, gender and school level were the four main predicting variables affecting childhood underweight. Hypertension was not significantly associated with childhood underweight.

**Conclusions:** The prevalence of childhood underweight was found to be high in children aged between five and 16 years. To address this problem, well-thought-out intervention systems are need.

**Keywords:** childhood underweight, blood pressure, hypertension, risk factor, CHAID decision tree

Childhood underweight is internationally recognised as a public health concern associated with negative health outcomes. The problem is reported to be on the rise in developing countries despite increased efforts to address it. In Africa, its prevalence was projected to have increased from 24.0% in 1990 to 26.8% in 2015, an increase of 12%. Childhood underweight is also a problem in South Africa, especially among school-aged children. Available data indicate that approximately one in 10 children is underweight in South Africa, and this phenomenon is at higher levels in rural areas.

Previous studies in this field have identified various factors that are believed to be associated with childhood underweight. These include, among others, socio-demographics such as age (15–24 years), gender (female), race (black), lower educational level, lower household income, behavioural (food insecurity, low energy levels, inadequate food intake, diets low in diversity and with insufficient nutrient density, as well as tiredness and poor perceptions of body image or fear of being fat).

In addition to socio-demographic and behavioural factors, cardio-metabolic risk factors such as hypertension have also been reported to be associated with underweight. The co-existence of both these conditions with underweight have proved to cause adverse cardiovascular events.

Although available, few studies exist in South Africa, particularly in the study area investigating childhood underweight, hypertension and associated risk factors. Yet research studies demonstrate a growing prevalence of underweight during the ageing process. Therefore, this study aimed to investigate the prevalence and associated factors of childhood underweight in a rural sample of young black South Africans who participated in the Ellisras Longitudinal Study.

**Methods**

This cross-sectional study is part of the ongoing Ellisras Longitudinal Study (ELS) design that started in 1996. Sampling was conducted as reported elsewhere. Briefly this study comprised 1 811 pre-primary and primary school children (934 males and 877 females), aged between five and 16 years, who were evaluated in 2000.

The Ethics Committee of the University of Limpopo granted ethical approval prior to the study. Written informed consent was obtained from the parents or guardians of the children.

Height was measured to the nearest 0.5 cm using a stadiometer. Weight was taken to the nearest 0.1 kg using a calibrated...
digital bathroom scale.\textsuperscript{19} Body mass index (BMI) was calculated as weight in kg divided by the square of height in metres. BMI = weight (kg)/height (m\textsuperscript{2}).\textsuperscript{17}

Growth charts published in 2000 from the Centre for Disease Control and Prevention (CDC) were used to plot BMI against age in both genders.\textsuperscript{18} Body mass index percentile and BMI z-score were estimated according to these charts. A BMI value at or greater than the 95th percentile was defined as obesity and a value between the 85th and 95th percentile for age and gender was considered overweight. Underweight was defined as a BMI value less than the 5th percentile.

All subjects were classified as overweight and obese according to the Cole \textit{et al.} cut-off point.\textsuperscript{19} The international cut-off points for undernutrition (grade one, two and three) by gender for exact ages defined to pass through BMI of 16, 17 and 18 kg/m\textsuperscript{2} were used.\textsuperscript{20,21}

Systolic and diastolic blood pressure (BP) were measured to the nearest 1 mmHg by trained fieldworkers on all participants in a seated position, with a calibrated M5-I digital automatic blood pressure monitor. Three consecutive measurements were taken and the mean of the last two systolic (SBP) and diastolic blood pressure (DBP) values was calculated and used to determine the blood pressure status. High blood pressure was defined as a SBP and/or DBP value greater than the 95th percentile at the standard age–gender–height percentile-specific blood pressure table.\textsuperscript{22}

### Statistical analysis

The chi-squared automatic interaction detection (CHAID) decision tree analysis is a classification method for building decision trees, using the chi-squared test to determine the best next split. It first examines the cross-tabulations between each responder and predictor variables, and chooses the predictor variable with the smallest adjusted \( p \)-value. The CHAID decision tree analysis was applied to identify factors and determine their relationships with underweight children. In CHAID analysis, underweight was the target variable and risk factors were explanatory variables. SPSS version 25.0 (IBM SPSS Statistics) was used for descriptive and CHAID decision tree analyses.

### Results

Table 1 shows the general characteristics of the study participants, including underweight status, gender, blood pressure status, nutrition, school level and age group. Overall, 19.5\% of the children were not underweight, while 80.5\% were underweight. Hypertension was found in 1.3\% of these children and 98.7\% were not hypertensive. Table 2 demonstrates the distribution of hypertension status and childhood underweight. Although it was not found to be significant, the prevalence of hypertension was seen to be higher among underweight children (65.2\%) than those not underweight.

Results of the CHAID decision tree analysis are presented in Fig. 1. The model demonstrated multilevel interaction among risk factors through stepwise pathways to detect childhood underweight. The model included gender, age group, school level, and blood pressure and nutritional status. Before and after adjusting for known confounders, predicting variable blood pressure status was not found to be statistically associated with childhood underweight. The final model showed that there were four main predicting variables affecting childhood underweight: the first variable was split on nutrition, followed by age group, gender and school level, with a significance level of \( p < 0.05 \).

Looking at the underweight children who had moderate or severe undernutrition, the model was able to predict that those children would be underweight roughly 99.8\% of the time. This prediction applied to 509 children and the model was accurate 508 times.

Our results showed that in underweight children who had normal nutrition and were between the ages of five and seven years, we were able to accurately predict that they would be underweight around 99\% of the time. Alternatively, if children were between eight and 10 years of age and still at pre-school, we predicted that they would be underweight 88\% of the time. This applied to 146 children and we were accurate about 128 times.

Looking at underweight children who had mild undernutrition and were between the ages of five and 10 years, we were able to accurately predict that they would be underweight 100\% of the time. Alternatively, if children were between 11 and 16 years of age and were male, we predicted that they would be underweight 93\% of the time. This applied to 219 children and we were accurate about 204 times.

### Discussion

Our results show a high prevalence of childhood underweight, confirming previous findings,\textsuperscript{12} and the continued existence of

| Table 1. General characteristics of the study participants |
| --- | --- | --- |
| Variables | Number | Percentage |
| Gender | | |
| Male | 934 | 51.6 |
| Female | 877 | 48.4 |
| Age categories | | |
| 5 – 7 years | 140 | 7.7 |
| 8 – 10 years | 649 | 35.8 |
| 11 – 13 years | 989 | 54.6 |
| 14 – 16 years | 33 | 1.8 |
| Educational level | | |
| Primary school | 1334 | 73.7 |
| Pre-school | 477 | 26.3 |
| Underweight | No | 354 | 19.5 |
| Yes | 1457 | 80.5 |
| Hypertension | No | 1788 | 98.7 |
| Yes | 23 | 1.3 |
| Nutrition | Normal | 671 | 37.1 |
| Severe undernutrition | 186 | 10.3 |
| Moderate undernutrition | 323 | 17.8 |
| Mild undernutrition | 631 | 34.8 |

| Table 2. Chi-squared test for the association between hypertension and underweight |
| --- | --- | --- |
| Variables | Hypertension, n (%) | Chi-squared test p-value |
| Underweight | | |
| No | 346 (19.4) | 8 (34.8) | 0.064 |
| Yes | 1442 (80.6) | 15 (65.2) |
| Total | 1788 | 23 |
underweight, among other health issues in young black African populations.\textsuperscript{24-26} The overall prevalence of childhood underweight in our study was 80.5%. The high underweight prevalence in this rural South African population may be indicative of lower socio-economic status occurring in the context of low wealth index and low intake of n-6 poly-unsaturated fatty acids as well as an overall high rurality index, which has previously been associated with underweight.\textsuperscript{23,27}

Supporting previous literature,\textsuperscript{28} this study indicates that blood pressure may not be a determinant of childhood underweight. The study furthermore shows that hypertension prevalence was higher among underweight children than in those not underweight and it confirms a previous study.\textsuperscript{29}

**Factors predicting childhood underweight**

Nutritional status: our study detected that nutrition was the first predictor in the decision tree, indicating that it was the most important risk factor for childhood underweight. Of the total sample, moderate and severe undernutrition appeared to be the most important, followed by mild undernutrition (92%) and normal nutrition (54.8%). The high prevalence of undernutrition among childhood underweight found by Black et al.\textsuperscript{30} corresponds with the findings of our study.\textsuperscript{29}

Age: consistent with previous studies,\textsuperscript{14,31} our analysis has shown that age group was another important risk factor for childhood underweight. The study detected that mild undernutrition in children aged between five and 10 years was a

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**Fig. 1.** The CHAID decision tree analysis to identify the factors of childhood underweight in Ellisras.
predictor of childhood underweight, which is in agreement with a previous study conducted in a rural South African population. The reason for this being a predictor may be that the abdominal muscles weaken as an individual gets older, decreasing BMI.

Gender and educational level: replicating consistent research results from rural black South African populations, this study has demonstrated a significant association of gender (male) and educational level (pre-school) with childhood underweight.

**Strength and limitations**

This study has both strengths and limitations. Among the strengths, standardised techniques were used, which included anthropometric and blood pressure measurements and the WHO STEPS questionnaire. Another includes the availability of data concerning various potential confounders.

The authors could not adjust maturation status in the analysis as a possible confounder for hormonal changes with undernutrition in boys, as reported previously. The study population comprised participants from the Ellisras rural population. This limits the external validity of the study in that results cannot be generalised to the total Limpopo Province population. The results, therefore may not be generalisable to the greater community outside this group. Due to the fact that this was a secondary data analysis, there was no control over what data were collected, or how they were collected or managed. The study was cross-sectional, preventing the assertion of a causal association of demographic, socio-economic and cardiometabolic risk factors with underweight.

**Conclusion**

Our results have shown a high prevalence of childhood underweight in a rural sample of young black South Africans, indicating a village-level burden. A CHAID decision tree identified different interactions between predictor variables of childhood underweight. Mild undernutrition in a male child aged 11 to 16 years, normal nutrition in a pre-school child aged between eight and 10 years, and moderate or severe undernutrition in a child aged five to 10 years were highly associated with childhood underweight. However being hypertensive was not associated with childhood underweight, suggesting that hypertension may not be clinically relevant in young black South Africans for the prediction of childhood underweight. Further research is needed to explore the risk of blood pressure on underweight adults.

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