https://doi.org/10.51745/najfnr.6.14.218-234

https://www.najfnr.com

REVIEW ARTICLE

# Nutritional status of school-age children and adolescents in eastern and southern Africa: A scoping review

**Rachael Menezes [1]*, Megan Deeney [1], Stephanie V. Wrottesley [2], Natasha Lelijveld [2]**

1. London School of Hygiene and Tropical Medicine London, England, WC1E 7HT, United Kingdom 02076368636. E-mail: rachael@ennonline.net / Megan.Deeney@lshtm.ac.uk
2. Emergency Nutrition Network (ENN) Oxfordshire, England, OX5 2DN, United Kingdom. 01865 372340. Email: natasha@ennonline.net / stephanie@ennonline.net

## ABSTRACT

**Aims:** This review aims to summarize available literature on the nutritional status of school-age children (SAC) and adolescents aged 5-19 years in Eastern and Southern Africa (ESA) and interventions aiming to tackle malnutrition in this age group. **Methods:** We searched Pubmed, Cochrane Database of Systematic Reviews, Web of Science, Africa Wide Information, ArticleFirst, Biomed Central, BioOne, BIOSIS, CINAHL, EBSCOHost, JSTOR, ProQuest, Google Scholar, SAGE Reference Online, Scopus, ScienceDirect, SpringerLink, Taylor & Francis, and Wiley Online for articles published between 2005 and 2020 according to eligibility criteria. **Results:** A total of 129 articles were included, with the majority of studies presenting data from Ethiopia (N = 46) and South Africa (N=38). The prevalence of overweight and obesity ranged between 9.1 – 32.3 % and 0.8 – 21.7 % respectively across countries in ESA. Prevalence of thinness, stunting and underweight ranged as follows: 3.0 – 36.8 %; 6.6 – 57.0 %; 5.8 – 27.1 %. Prevalence of anemia was between 13.0 – 76.9 % across the region. There was a dearth of data on other micronutrient deficiencies. There was limited evidence from intervention studies (N = 6), with half of the interventions targeting anemia or iron deficiency using iron supplementation or fortification methods and reporting no significant effect on anemia prevalence. Interventions targeting stunting and thinness (N = 3) reported beneficial effects of providing vitamin A fortified maize, iron supplementation and nutrition education. **Conclusions:** A triple burden of malnutrition underlines the need to prioritize implementation of double-duty interventions for SAC and adolescents in ESA. Key data gaps included either limited or a lack of data for the majority of countries, especially on micronutrient deficiencies and a scarcity of intervention studies. Greater investment in nutrition research amongst this population is needed to strengthen the evidence base and inform policies and programs to improve nutritional status amongst SAC and adolescents in ESA.

**Keywords.** Adolescence, overnutrition, undernutrition, micronutrient deficiencies, Interventions.

## ARTICLE INFORMATION

*Corresponding author: Rachael Menezes: rachael@ennonline.net

**Received:** September 14, 2022
**Revised:** December 24, 2022
**Accepted:** December 25, 2022
**Published:** December 31, 2022

**Article edited by:**
- Pr. Mustapha Diaf

**Article reviewed by:**
- Pr. Meghit Boumediene Khaled
- Dr. Basil H. Aboul-Enein

**Cite this article as:** Menezes, R., Deeney, M., Wrottesley, S.V., & Lelijveld, N. (2022). Nutritional status of school-age children and adolescents in eastern and southern Africa: A scoping review. *The North African Journal of Food and Nutrition Research, 6* (14): 218-234. https://doi.org/10.51745/najfnr.6.14.218-234



## 1 Introduction

Adolescence (10 – 19-year-olds) is a period of significant and rapid physical, emotional and behavioral growth which shapes health outcomes in adulthood, as well as in the next generation[1, 2]. The health and nutrition of school-age children (SAC; 5 – 9-year-olds) is also important, as under- or overnutrition directly impacts physical development, educational achievement, and future health outcomes in this age group as well [3]. However, there is minimal representation of SAC and adolescents in global and national reporting, with research, policy and programming efforts being focused on the nutritional status of other demographics [4].

The UNICEF region of Eastern and Southern Africa (ESA) has experienced rapid economic and nutritional change over the past few decades. Weak economic growth and adverse climate conditions have had catastrophic effects on agricultural production, led to falling commodity prices of key exports and forced millions into crisis. These circumstances have resulted in a sharp rise in undernutrition, amplifying the existing food insecurity crisis and further contributing to an unstable food environment for SAC and adolescents [5]. Furthermore, the rapid nutrition transition amongst low- and middle-income countries (LMICs) has led to an emerging triple burden of malnutrition, where undernutrition and MN deficiencies persist alongside rising burdens of overweight and obesity [6]. Globally, prevalence of overweight (including obesity) in SAC has risen to 24.5 % in boys and 21.4 % in girls. Similar figures have been reported in adolescents, with 20.2 % of boys and 18.4 % of girls being overweight and obese. Global prevalence of thinness amongst SAC is 10.9 % in boys and 8.9 % in girls, while the figures for adolescents are 12.3 % in boys and 7.9 % in girls [4]. Both over- and undernutrition across the school-age and adolescent years have implications on physical and cognitive development, with associated risks for school attendance, academic performance and productivity in adulthood, as well as for susceptibility to developing non-communicable diseases (NCDs) in later life [3, 6, 7].

The current nutrition situation across ESA, combined with the triple burden of malnutrition amongst SAC and adolescents globally, as well as the lack of representation in global reporting, has detrimental implications for the nutrition and health status of current and future generations [7]. Thus, it is vital to summarize existing research describing the nutritional status of SAC and adolescents in ESA, to explore successful interventions implemented within this population and to identify research gaps. This will help to inform research, policy and programming agendas in the region towards addressing the nutritional needs of this population, thereby optimizing pubertal growth and development and breaking the intergenerational cycles of malnutrition and chronic diseases in adulthood [8].

This review aimed to summarize the available research describing the nutritional status of SAC and adolescents 5 – 19 years of age in ESA, as well as interventions targeting malnutrition in this population.

# 2 Methods

## 2.1 Searh strategy

The literature search was carried out using nineteen electronic databases: Pubmed, Cochrane Database of Systematic Reviews, Web of Science, Africa Wide Information, ArticleFirst, Biomed Central, BioOne, BIOSIS, CINAHL, EBSCOHost, JSTOR, ProQuest, Google Scholar, SAGE Reference Online, Scopus, ScienceDirect, SpringerLink, Taylor & Francis, and Wiley Online. This review was conducted according to the PRISMA guidelines for scoping reviews (for full checklist see Supplementary Appendix 1, available online at: http://www.prisma-statement.org/Extensions/ScopingReviews.
The search terms are detailed in Supplementary Appendix 2 and inclusion/exclusion criteria is presented in Table 1, guided by the "Population, Interventions, Control and Outcome" (PICO) framework. The classification of anthropometric measurements and micronutrient status we used are detailed in Table 2. The countries 21 included in this review were: Angola, Burundi, Botswana, Comoros, Eswatini, Eritrea, Ethiopia, Lesotho, Kenya, Madagascar, Mozambique, Malawi, Namibia, Rwanda, Somalia, South Africa, South Sudan, Tanzania, Uganda, Zimbabwe, and Zambia.

**Table 1.** "PICO" framework

| | | |
|---|---|---|
| P | **Population** | - School-aged children (SAC) and adolescents aged 5 – 19-year-olds, living in the UNICEF region of Eastern and Southern Africa.<br>- Studies where the subjects were pregnant or had diagnosed diseases were not included |
| I | **Intervention** | - None required; in identifying data on nutritional status no intervention was required, though we included baseline data from interventions, surveys, cross-sectional data, etc.<br>- In identifying interventions that target nutritional status of adolescents, we included any form of intervention provided that it was designed to improve adolescent nutritional status. This included dietary and micronutrient supplementation interventions, social support interventions, educational interventions, behavior change interventions, etc. |
| C | **Comparison** | - None required; for studies reporting on prevalence data no comparison group was required.<br>- For interventions, comparison groups could include a control group that received no intervention, groups that received a different type of interventions or the same participant group before and after the intervention was administered. |
| O | **Outcome** | - Prevalence of stunting, thinness, underweight.<br>- Prevalence of the following micronutrient deficiencies (anemia, iron deficiency, iodine deficiency, vitamin A deficiency, vitamin D deficiency, vitamin C deficiency, zinc deficiency).<br>- Prevalence of overweight and obesity.<br>- Dietary patterns (e.g., eating habits, dietary diversity, food consumption, etc.) |
| **Additional inclusion criteria** | | - Only peer-reviewed human studies published since the year 2005.<br>- No restrictions on study design. |
| **Additional exclusion criteria** | | - Studies involving children/adolescents with a diagnosed disease.<br>- Studies involving pregnant adolescent girls. |

**Table 1.** Classification of anthropometric measurements and micronutrient status

| Outcome | Classification |
|---|---|
| Stunting | - <-2SD height-for-age Z-score (WHO growth reference values (GRV)) |
| Thinness | - <-2SD BMI-for-age Z-score (measure for thinness) (WHO GRV) |
| Underweight | - For 5 – 10-year-olds: <-2SD weight-for-age Z-score (WHO GRV) |
| Anemia | - For 5 – 11-year-olds: Hb (hemoglobin) concentration of < 11.5g/dL.<br>- For 12 – 14-year-olds and non-pregnant women 15-19 years old: Hb concentration of < 12.0 g/dL.<br>- For boys 15 – 19-year-olds: Hb concentration of <13.0 g/dL.<br>- (WHO anemia cut-offs) |
| Iron deficiency anemia | - For > 5-year-olds: Serum ferritin of <15.0µg/L AND anemia cut-offs above (WHO anemia cut-offs & WHO serum ferritin cut-offs) |
| Iron deficiency | - For > 5-year-olds: Serum ferritin of <15.0 µg/L (WHO serum ferritin cut-offs 2011) |
| Iodine deficiency | - For > 6-year-olds: Urinary iodine excretion of <100 µg/L (WHO iodine status indicators) |
| Vitamin A deficiency | - For all age groups: Serum retinol concentration of < 0.7 µmol/L (< 20 µg/dL) (WHO serum retinol cut-offs) |
| Vitamin D deficiency | - 25 (OH)D level of ≤ 20 ng/mL (The Endocrine Society classification for vitamin D deficiency) OR<br>- 25(OH)D concentration of < 50 nmol/L (cut-offs taken from Holick MF, 2007, "Vitamin D deficiency", journal article published in *New England Journal of Med*) |
| Vitamin C deficiency | - For all age groups: Serum ascorbic acid level of < 0.3 mg/100mL (WHO serum ascorbic acid cut-offs) |
| Zinc deficiency | - For < 10-year-olds: Serum zinc level of <65 ug/dL (WHO/UNICEF serum zinc status indicators) |
| Overweight | - For 5 – 19-year-olds: Overweight (> 1SD BMI-for age Z-score) (WHO BMI cut-offs 2006) OR<br>- Overweight (85th -> 95th percentile) (CDC obesity and overweight cut-offs 2004) OR<br>- Overweight (BMI cut-offs based on sex) (IOTF cut-offs 2012) |
| Obesity | - For 5 – 19-year-olds: Obesity (> 2SD BMI-for-age Z-score) (WHO BMI cut-offs 2006) OR<br>- Obesity (> 95th percentile) (CDC obesity and overweight cut-offs 2004) OR<br>- Obesity (BMI cut-offs based on sex) (IOTF cut-offs 2012) |

## 2.2 Screening process and study selection

The search results from each database were extracted and imported into Mendeley reference management software. Firstly, all duplicates were removed and the results were screened on the eligibility criteria based on their title and abstract. Full texts of the remaining results were then screened for eligibility according to the inclusion and exclusion criteria.

## 2.3 Data extraction

The following data was extracted from all relevant research articles that met the inclusion/exclusion criteria: author, date, country that the research took place in, year of data collection, target population (including age of subjects, sex and sample size), outcomes of interest, classification criteria used and key findings from the literature (including any relevant interventions or programs that were implemented). This data is presented in Supplementary Appendix 3.

# 3 Results

The last database search was conducted on 21st December 2022. Searches produced 6566 results which were screened by title and abstract. Following screening of the remaining 838 full texts, a total of 129 studies were included in this review. Figure 1 presents a flow diagram of the study selection process and the data extracted from the 129 articles included in this review are summarized in the Supplementary Appendix 3.

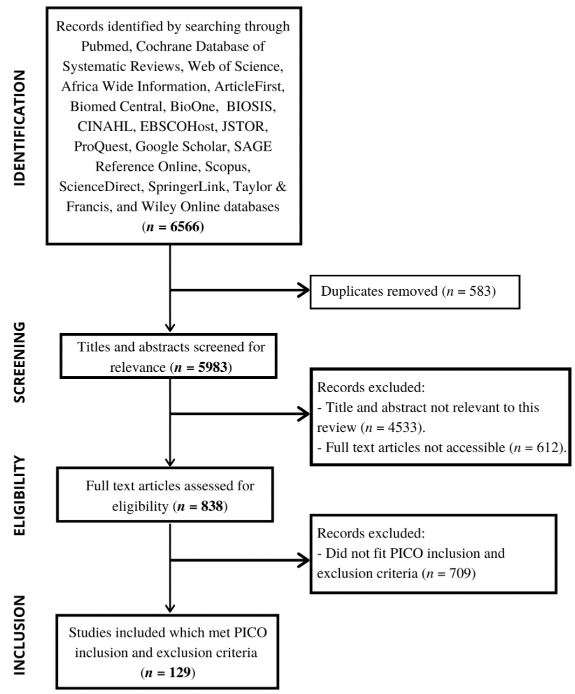


**Figure 1.** A flow diagram detailing the study selection process

The included articles reported prevalence rates for one or more of the following outcomes: thinness, stunting, underweight, overweight, obesity, dietary patterns, various micronutrient deficiencies and any risk factors associated with one or more of the previous outcomes. Of the 129 studies, a total of six involved a nutrition intervention. The majority of the studies included came from Ethiopia (N = 46) and South Africa (SA) (N = 38), with a total of seven (7) countries within ESA presenting no data that met the inclusion criteria for this review (Table 3).

**Table 3.** Literature review search results by country

| Country - Number of included studies (%) | |
|---|---|
| Angola - 1 (0.7 %) | Mozambique - 5 (3.8 %) |
| Botswana - 1 (0.7 %) | Namibia - 0 (0.0 %) |
| Burundi - 1 (0.7 %) | Rwanda - 0 (0.0 %) |
| Comoros - 0 (0.0 %) | Somalia - 0 (0.0 %) |
| Eritrea - 0 (0.0 %) | South Africa - 38 (29.4 %) |
| Eswatini (Swaziland) - 0 (0.0 %) | South Sudan - 0 (0.0 %) |
| Ethiopia - 46 (35.6 %) | Tanzania - 11 (8.5 %) |
| Kenya - 5 (3.8 %) | Uganda - 6 (4.6 %) |
| Lesotho - 2 (1.5 %) | Zambia - 2 (1.5 %) |
| Madagascar - 1 (0.7 %) | Zimbabwe - 2 (1.5 %) |
| Malawi - 2 (1.5 %) | Multi-country studies - 7 (5.4 %) |
| **Total: 129 (100.0%)** | |

## 3.1 Narrative results by nutritional outcome

### 3.1.1 Thinness

A total of 30 studies described the prevalence of thinness. Although many of the studies used the terms “wasting”, “underweight” and “thinness” interchangeably, since all studies used BMI-for-age to classify this (see Table 2) we will use the term “thinness” throughout. Prevalence of thinness across ESA was 3.0 – 36.8 %. Research from Ethiopia, Kenya, South Africa (SA), Malawi and Tanzania observed thinness prevalence rates between 11.0 – 36.8%, amongst 10 – 19-year-olds [9 - 24]. Data from Madagascar, Mozambique, Uganda, Kenya and Ethiopia reported thinness prevalence rates of 3.3 – 14.9 % in younger adolescents [25-30]. Research from Madagascar further reported that 4.8 % of its adolescent population suffered from concurrent thinness, stunting and underweight [26], while 3.4 % of the adolescent population in SA were severely thin [31].

Two studies presented data on the change in thinness prevalence over time, with contrasting results. Data from a repeated cross-sectional study in Mozambique reported a decline in thinness prevalence from 19.2 % to 12.0 % between 1992 and 2012 amongst 8 – 15-year-olds [32]. Zimbabwean national data reported an increase in thinness prevalence from 3.1 % to 3.6 % between 2009-2011 amongst primary school children (age not specified) [33].

Several studies identified risk factors for thinness amongst 5 – 19-year-olds. Two studies highlighted the difference between boys and girls, with one study reporting that girls were thinner than boys (29.1 % vs. 18.2 %) [28], while another study observed a higher thinness prevalence in boys when compared to girls (22.2 % vs. 10.6 %) [19]. Three studies suggested rural (vs. urban residence) as a predictor of thinness [29, 22, 34], with one study finding that urban adolescents were 65.0 % less likely to be thin [34]. Other factors including poverty, FI [17, 22, 34] poor WASH practices [27] and lower socio-economic status [19] were also associated with higher prevalence of thinness.

Only one intervention aimed to reduce the prevalence of thinness. Participants were 11-19 years old and received bi-monthly nutrition education sessions, resulting in a significant ($p < 0.001$) 3.0 % decrease in prevalence of thinness in the intervention group and no change from baseline in the control group [12].

### 3.1.2 Stunting

Prevalence of stunting across ESA was reported by 40 studies, ranging between 6.6 – 57.0 % (Figure 2). Research conducted in Ethiopia, Kenya, SA, Tanzania and Uganda showed that 12.0 – 13.0 % of 10 to 19-year-olds were stunted [9 - 11, 15, 17, 22 - 24, 26, 35 - 40,] and that 6.6 – 57.0 % of 5 to 15-year-olds were stunted [18, 25, 27, 28, 30, 41 - 45]. There was no indication of any major differences between stunting in older and younger adolescents, as prevalence figures were within a relatively similar range amongst both age groups.

Two studies showed a decrease in stunting prevalence over time. One cross-sectional study from Mozambique reported a decline from 14.8 % to 11.1 % between 1992 – 2012 amongst 8 to 15-year-olds [28], while a second study conducted in Zimbabwe (2003 – 2011) observed a decrease in stunting prevalence from 10.2 – 7.4 % in boys and 7.8 – 4.4 % in girls [28].

Three studies reported an association between sex and prevalence of stunting [31, 43, 46]; one study reported that the prevalence of stunting was 15.0 % higher in boys than in girls (65.7 % vs. 50.7 %) [28]. Additionally, rural (vs. urban dwelling) was highlighted as a predictor of stunting [18]. One study revealed that stunting prevalence in rural adolescents was 47.9

%, nearly six times higher than the 8.1 % of urban adolescents (aged 10 – 19 years) who were stunted [37]. Other studies reported that SAC and adolescents whose parents worked in "unskilled" roles, girls who had not yet started menstruating and adolescents who did not snack during the day all were associated with high prevalence of stunting [10, 15, 31].

One intervention study from Zambia involved 4 – 16-year-olds attending nutrition and sanitation education sessions as part of a school health program to reduce stunting prevalence. Researchers reported a baseline stunting prevalence of 15.0 %, with a 5.7 % decrease in stunting in the intervention group as opposed to a 3.5 % increase in stunting prevalence in the control group [47].

### 3.1.3 Underweight

A total of seven (7) studies reported on the prevalence of underweight which ranged between 5.8 – 27.1% across the region. Data from Ethiopia, Kenya, Tanzania and Uganda reported that 5.8 – 27.1 % of 5 to 10-year-olds were underweight [30, 40, 41, 43]. The prevalence rates were 36.9 % and 81.0% in studies from Madagascar and South Africa respectively [48].

Three studies reported sex as a predictor of underweight. Research from Tanzania, Malawi and Ethiopia all reported that boys were more at risk of being underweight than girls [43, 46]; one study reported that underweight prevalence was twice as high in boys as it was in girls (24.4 % as opposed to 12.4 %)[16]. No intervention studies were identified which targeted underweight.

### 3.1.4 Overweight and obesity

A total of 50 studies were found that reported on overweight and obesity prevalence in SAC and adolescents. Prevalence of obesity across ESA ranged from 0.8 – 21.7 %, with the highest figures being reported in Uganda (21.7 %) and the lowest figures reported in Malawi (0.8%) [22, 45, 49 - 69]. Overweight prevalence rates also varied across ESA, with figures ranging from 9.1 – 32.3 %. The highest rates of overweight were identified in Uganda, while the lowest figures were found in Mozambique [22, 30, 36, 43, 45, 50-58, 60- 62, 64-66 70-76]. A total of 14 studies presented combined overweight and obesity prevalence data, reporting figures of between 6.1 – 17.8 % [14, 43, 77-88].

Nine studies showed that girls were at a higher risk of obesity than boys [43, 59, 60, 74, 82, 83, 89-91]. Research from SA, Ethiopia, Kenya, Tanzania, Uganda, Mozambique, Zimbabwe and Lesotho also suggests urban (vs. rural) dwelling, age, low parental level of education and high consumption of processed snacks/sweetened beverages as predictors of obesity [92]. A study in Ethiopia highlighted that attending private school (vs. public school), higher socioeconomic class, preferring sweetened beverages, spending more time watching tv and playing computer games were all positively associated with both overweight and obesity [57]. Research from SA presented similar findings, stating that high socioeconomic status and increased access to resources were determinants of obesity [79]. However, another SA study reported the opposite, that the odds of obesity increased by 40.0 % in households where the head of the family had not completed secondary school education and where families were of a lower socioeconomic status [82]. No intervention studies were identified which targeted overweight and obesity.

### 3.1.5 Anemia and iron deficiencies

A total of 29 studies presented data on the prevalence of anemia, iron deficiency anemia (IDA) and iron deficiency; there was no clear separation between data on older and younger SAC and adolescents as most studies encompassed both sub-groups into their samples (Figure 3). Studies from Burundi, Kenya, Mozambique and Uganda presented similar prevalence figures for anemia, between 42.4-53.0% for older adolescents aged 10 – 19-years-olds [70, 93 - 96] However, one study from Uganda reported closer to one quarter of adolescents were anemic [25] Similar observations were seen in SA and Zambia, reporting anemia prevalence as 13.0 – 25.0 % amongst 5 – 19-year-olds [93, 97, 99 - 101]. An article from Tanzania reported an incredibly high anemia prevalence of 79.6 % in 7 – 14-year-olds [102]. There were 9 studies from Ethiopia presenting data on anemia and iron deficiencies, with prevalence data ranging from 10.0-43.7% for anemia [13, 20, 22, 41, 103 - 106] and 13.0 – 37.4 % for IDA [104]. Various risk factors of anemia were also identified, such as rural (vs. urban residence) being a factor [20, 94]. Other papers identified that low dietary diversity (DD), FI and poor accessibility to iron-rich foods were all predictors of anemia [96, 105, 107]. Data on prevalence of IDA across the whole region ranged from 6.0 – 43.0 % [96, 97, 99 104, 108]. However, the majority of studies concerning iron deficiency alone reported figures between 29.0 – 36.0 % [44, 70, 93, 98, 102] and spanned across multiple countries within ESA. Two studies from Ethiopia and Uganda presented data that was outside of this range; reporting a prevalence of 13.0 % [93], and a prevalence of 82.1 % [25].

Three interventions targeted anemia and iron deficiencies. One study from Zambia, involving maize meal fortified with iron, observed a 0.24 g/dL increase in Hb concentration (95 % CI: 0.01, 0.47, p = 0.043) in the intervention group (10 – 19-year-olds). This study did not include a control group due to operational constraints that may have negatively impacted the implementation of this intervention [98]. Research from Burundi adopted a similar approach and fortified rice with iron. The study reported that both the intervention and control group showed a 1.0 g/dL increase in Hb concentration but the intervention group showed a 0.09 g/dL greater increase in Hb concentration ($p < 0.05$) (aged 7 – 11-year-olds) than the control [95]. The third intervention, in Mozambique, involved implementing an iron supplementation program over five months amongst 10 to 18-year-olds. The findings showed a 7.0 % decrease in anemia prevalence in the intervention group vs. the control group (28 % vs. 35 %, p = 0.076) [109].

### 3.1.6 Iodine deficiency

A total of 10 studies presented data on iodine deficiency. Research from Uganda reported a prevalence of iodine deficiency, at 3.4 % amongst 9 to 15-year-olds [25]. Iodine deficiency was also found in Ethiopia (13.7 % amongst 6 to 12-year-olds [110]) and in SA (15.0 % amongst 10 to 19-year-olds [111]. However, older studies from Ethiopia reported a prevalence of 86.0 % in 2005 [111] and 31.0 – 5 8.8 % between 2011 – 2015 [110, 112 - 114]. Researchers concluded that iodine deficiency is still a public health concern in Ethiopia, despite universal iodization of salt, suggesting that SAC and adolescents need more targeted counselling/education to increase iodine-rich food consumption. Contrarily, researchers from Lesotho declared iodine deficiency no longer a public health problem after observing a decline in prevalence from 42.4 % to 21.5 % between 1993 – 2002 [108]. Two studies from Tanzania found that one quarter of adolescents are iodine deficient, while 9.3 % of 6 to18-year-olds had a very low urinary iodine concentration of < 50mg/L [115, 102].

### 3.1.7 Vitamin A deficiency

A total of 10 studies presented data on vitamin A deficiency. Data from Tanzania and Uganda showed that the prevalence of vitamin A deficiency ranged from 30.3 – 31.9 % amongst SAC and adolescents [25, 102]. In Kenya, vitamin A deficiency was 30.0% in younger adolescents (7 – 10 years) [44], while 14.0 % of 10 to 19-year-olds were reported as vitamin A deficient in another study [93]. Three studies conducted on SA adolescents (5 – 19 years) reported a deficiency prevalence of between 42.0 – 70.9 % [71, 93, 111]. A fourth study from SA suggested a lower prevalence of 7.0 % [99]. Studies from Mozambique and Ethiopia reported vitamin A deficiency prevalence rates of 12.0 % [111] and 4.1 % [70], respectively amongst 5 to 19 – year-olds. In Zambia, maize meal fortified with vitamin A was reported as an effective intervention in reducing vitamin A deficiency; a 26.1 % decrease in vitamin A deficiency (p < 0.001) was observed in the intervention group. This study did not include a control group due to operational and ethical considerations [98].

### 3.1.8 Vitamin D deficiency

There were 3 studies identified that reported on vitamin D deficiency. In Ethiopia, 42.0 % of 11 to 18-year-olds were found to be deficient in vitamin D. Researchers also reported that urban adolescents were three times more likely to be vitamin D deficient than rural adolescents (61.8 % vs 21.2 %)[50]. However, a lower prevalence was reported in SA, with two studies observing only a 7.0 % prevalence of vitamin D deficiency [116, 117].

### 3.1.9 Zinc deficiency

A total of seven (7) studies presented data on zinc deficiency. Research from Kenya reported that 3.0 % of 7 to 10-year-olds were zinc deficient [44], whereas 9.6 % and 14.7 % of 14 to 19-year-olds were deficient in Ethiopia and Mozambique, respectively [70, 118]. Data from SA, however, reported higher figures between 37.0 – 75.6 % [93, 99, 111, 119]. Sex differences were identified, with boys having an increased likelihood of zinc deficiency [118]. FI and poverty were also identified as risk factors for zinc deficiency [119].

### 3.1.10 Vitamin C deficiency

No studies were found on vitamin C that met the PICO criteria.

### 3.1.11 Dietary patterns

A total of 21 studies explored dietary intakes, patterns and eating attitudes of SAC and adolescents across ESA. Data on dietary diversity (DD) from Ethiopia and Malawi revealed that 32.3 – 75.4 % of adolescents (7 to 17-year-olds) met minimum DD [120, 121], with further research from both countries, as well as data from Uganda, stating that 45.3 – 80.0 % of adolescents did not meet minimum DD [123, 123]; 69.0 % of adolescents did not meet minimum dietary requirements for energy and 21.0 % did not meet the requirements for fat intake [121]. Data from Lesotho reported low DD amongst 16-year-olds, with 91.4 % of adolescents consuming <3 portions of vegetables per day and 84.6 % consuming <2 portions of fruit per day [87]. Research highlighted that low DD was associated with adolescents (aged 15 – 17- year-olds) who were Muslim (aOR: 0.3, 95 % CI: 0.1, 0.7), self-employed (aOR: 0.3, 95 % CI: 0.1, 0.9) or in the high wealth category (aOR: 0.3, 95 % CI: 0.2, 0.6) [120]. A further two (2) studies reported that food insecurity (p < 0.001, OR not reported) and rural residency (p < 0.001, OR not reported) were both associated with low DD, while age (OR = 1.15, p = 0.004) and urban residency were associated with high DD [124] .

Qualitative data showed that 10 to17-year-olds in SA reported that lack of autonomy and ease to which they could access unhealthy foods were key drivers of unhealthy food choices [39]. Further research discovered that adolescents would often pool their money together to purchase food and share it - it was reported that the food bought was usually unhealthy non-traditional foods that were high in sugar / fat / salt [125, 126].

Foods consumed by adolescents varied between countries. Research from Mozambique revealed that amongst 14 to 18-year-olds, bread, fats, meat, vegetables, cassava and coconut were most commonly consumed [127]. Younger adolescents in Malawi, aged 7 – 9-year-olds, also commonly consumed vegetables (34.1 %) but only 12.0 % consumed animal food products [121]. This diet is somewhat different to SA adolescents (aged 10 – 17-year-olds) who reported high consumption of starchy foods, fats and oils and substantial intakes of salty snacks / cakes / sweets / fizzy drinks but low intakes of micronutrient-rich fruits and vegetables [71, 78].

The dietary intake of Ugandan adolescents had some similarities to adolescents from Mozambique, Malawi and SA, and was observed via 24 – hour recall. Diets consisted of: 99.7 % cereals/roots/tubers, 87.0 % fats & oils, 77.0 % sweets, 66.2 % legumes, 53.8 % other non-vitamin A-rich vegetables, 42.3 % dark green leafy vegetables, 33.1 % meat/poultry/fish, 32.9 % dairy products, 11.2 % eggs, 33.4 % vitamin A-rich fruits and vegetables and 8.2 % other fruits[123]. A second study discovered 55.0 % of adolescents consumed biscuits / cake / chocolate at least 3 – 5 times per week [128]. Further research from Uganda reported that girls, aged 5 – 19 years, had higher sugar intake scores than boys[128]. Supporting literature from SA revealed that girls had a higher frequency of eating sugary snacks and fried foods but a lower frequency of eating breakfast when compared to their male counterparts [90, 129]. In regards to breakfast consumption, one article reported that though many girls believed in the importance of breakfast, the majority skipped this meal [130], with only 28.4 % of girls consuming breakfast [121]. Conflicting research reported that 77.8 % adolescents did have breakfast, however almost the same number of adolescents (73.2 %) purchased unhealthy food items while at school – such as cola, pies and samosas [131].

One longitudinal study in SA tracked dietary patterns of adolescents over a 5 – year period (between the ages of 13 – 17-year-olds). The findings stated that breakfast consumption decreased from 76.0 % to 65.0 % over the 5 years, whereas snacking while watching TV increased from 3.6 to 6.7 snacks per week. Fast-food consumption increased by 0.5 portions per week, however the consumption of confectionery remained the same (9 – 10 items per week). A decrease in the consumption of micronutrient-dense foods and an increase in high sugar / fat / salt foods over the 5-year period was observed [129].

# 4 Discussion

This review summarized the existing literature on the nutritional status of SAC and adolescents in the ESA region, as well any interventions implemented to tackle malnutrition within this population. Though a total of 129 studies were included, several gaps in the data were identified as a total of seven countries presented no data on nutritional status amongst adolescents. Of the 14 countries that did present data, the majority of the evidence came from Ethiopia and SA (a total of 65.0 %, see Table 3) and is therefore not representative of the region as a whole. Several studies presented prevalence data on thinness, stunting, anemia and iron deficiency, overweight and obesity, however there was little research on iodine, vitamin A and D, and zinc deficiencies (with no countries reporting on vitamin C adequacy). There was also a lack of disaggregated data by age and sex. Limited evidence of interventions targeting malnutrition amongst SAC and adolescents was obtained (n = 6), further contributing to an incomplete understanding of nutritional status and how to address malnutrition in these age groups across the region.

We found evidence of a high prevalence of overweight and obesity amongst SAC and adolescents in ESA, 9.1 – 32.3 % and 0.8 – 21.7 %, respectively. Research indicates that this is likely a result of the nutrition transition, characterized by increased dietary intakes of foods that are highly processed, energy-dense and poor in micronutrients, alongside reduced levels of physical activity across sub-Saharan Africa [132]. Furthermore, data from children < 5 years in ESA estimates a stunting and thinness prevalence of 33.6 % and 6.2 %, respectively [133]. When compared with our findings, it suggests that undernutrition is still as much a public health concern for those > 5 years as it is for those < 5 years, highlighting that this should remain a priority as children age, in both research and action. In addition, our findings revealed that micronutrient deficiencies are very prevalent, in particular anemia, iron deficiency anemia and iron deficiency alone, ranging from 13.0 – 76.9 %, 6.0 – 43.0 %, and 13.0 – 82.1 %, respectively. These findings draw attention to the triple burden of malnutrition, whereby micronutrient deficiencies, in addition to over- and undernutrition, are prevalent across ESA. Research states that childhood and adolescent overweight and obesity increases the risk of NCDs in adulthood [6], while undernutrition and micronutrient deficiencies significantly damage physical / cognitive growth and also increase the risk of NCDs, with long-lasting effects [7]. The lack of any intervention studies in the region tackling overweight or obesity, nor the triple burden is deeply concerning.

As previously stated, the nutrition transition may be driving the triple burden of malnutrition across ESA. Several studies reported a shift in dietary patterns amongst SAC and adolescents, revealing suboptimal intakes of fruits and vegetables, not meeting minimum DD and skipping breakfast. Data also highlighted that, girls were more likely to consume unhealthy diets and to be obese than boys. Other risk factors for overweight and obesity included higher socioeconomic status, higher wealth category and higher parental education. Geographical differences were also observed, with subjects residing in rural settings disproportionately affected by thinness, stunting and underweight. Identification of these key predictors of nutritional status demonstrate the importance of sub-groups being targeted accordingly.

Despite the lack of intervention studies available, the delivery methods used by the few existing intervention studies may benefit future researchers when targeting this age group. Food fortification and micronutrient supplementation were techniques employed (N = 3) as well as behavioral change methods such as nutrition/health education (N=3). Creating programs that combine the efficiency of supplementation / fortification methods with the greater long-term impact of behavioral change techniques may be effective in improving nutritional status. The recent Lancet series on maternal and child undernutrition confirms this, with interventions that are both nutrition-specific and nutrition-sensitive having the greatest impact on health outcomes [134]. The paper further advocates for large-scale fortification and supplementation programs in targeting micronutrient deficiencies [134]. Current WHO recommendations detail additional fortification and supplementation of micronutrients for SAC and adolescents, including specific antenatal nutrition recommendations for adolescent girls [135]. However, given the lack of intervention data available across ESA, the evidence on implementation of these recommendations is poor.

Several research gaps were identified, including limited or no prevalence data on a number of micronutrient deficiencies, a lack of intervention studies, as well as no prevalence data for any nutrition outcomes from seven (7) countries within ESA. Our prevalence data on over- and undernutrition emphasizes the need for immediate action in targeting this increasing burden of malnutrition through tailored interventions. Sex differences and risk factors that we identified further support the need for targeted interventions that are both gender- and context – specific, considering not only the root issues of malnutrition but social factors affecting dietary intake as well.

Based on our findings, future interventions should also focus on improving food security, accessibility and affordability of nutritionally-dense foods, and complementary interventions promoting physical activity. In addition, it is crucial that SAC and adolescent diets need to become more sustainable overall, with the barriers to making healthy food choices also needing to be investigated. Interventions that address the driving forces behind poor eating habits and the nutrition transition should therefore be prioritized. As part of this approach, incorporating dietary counselling for young people from early adolescence may contribute to better management of the burden of malnutrition that is evident within this age group.

This review revealed that the implications of poor nutrition on future generations must also be considered, especially as this population approaches child-bearing age [136]. Our findings highlight the need to prioritize funding and action to improve adolescent nutrition; this would also present a key opportunity in improving maternal nutrition amongst adolescents, whether this be through multiple-micronutrient supplementation programs, family planning services or antenatal care services [137].

## 4.1 Limitations of this review

There are some limitations of this review that may have affected our ability to compare data accurately. The age range reported on was defined as 5 – 19 years, however there were variations between studies in regards to reporting on different subsets within this age range; some reported on older adolescents and others focused on younger children. Furthermore, a number of studies did not report the age of participants. Though this made it difficult to directly compare certain data sets, it was still possible to discuss these data sets independently.

Additionally, several different measurement techniques were used to assess dietary patterns which also restricted comparison of our data sets. Further inconsistencies between studies involved differing definitions of anthropometric nutritional status and micronutrient status. The majority of articles used the WHO 2007 Growth Reference to determine anthropometric z-scores [138]. However, eight papers used alternative references and thresholds (i.e., IOTF, CDC) to determine vitamin D, anemia and obesity status [50, 53, 57, 77, 82, 95, 116, 117]. Previous research suggests that researchers should be cautious when comparing data using different reference values[139, 140]; however, studies have also suggested that though there may be minor discrepancies between data sets using WHO, CDC and IOTF references, the overall estimates have excellent agreement in assessment of adolescent nutritional status and should not present any major issues when comparing data sets [142, 143].

# 5 Conclusions

In conclusion, our review found evidence that undernutrition, overnutrition and micronutrient deficiencies are a public health concern amongst SAC and adolescents across ESA, with sufficient evidence to confirm an emerging triple burden of malnutrition. Limited evidence from intervention studies identified food fortification, micronutrient supplementation and behavior change communication as useful strategies to target thinness, stunting and vitamin A deficiency. However, there was no nutritional prevalence data from seven (7) countries in the region as well as limited data on micronutrient deficiencies.

To fill these significant research gaps, there is an urgent need to invest in strengthening the evidence base for malnutrition in SAC and adolescents across the ESA region, as well as on effective intervention strategies. Given that the region is facing a triple burden of malnutrition, intervention strategies should incorporate “double duty” actions which simultaneously target multiple forms of malnutrition. This will promote optimal development and health outcomes for SAC and adolescents, while contributing to breaking intergenerational cycles of malnutrition.

**Acknowledgement:** The author would also like to thank The London School of Hygiene and Tropical Medicine, the lecturers, support staff and librarians for their sound advice and expert teaching.

**Author Contribution** RM is listed as the guarantor for this paper. RM, MD and NL contributed towards the concepts, design and definition of intellectual content. RM was responsible for the literature search, data acquisition, data analysis and manuscript preparation. RM, MD, NL and SVW contributed towards the manuscript editing and manuscript review. The final manuscript was read and approved by all co-authors.

**Funding (Source of support):** This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## References

[1] Patton, G. C., Sawyer, S. M., Santelli, J. S., Ross, D. A., Afifi, R., Allen, N. B., Arora, M., Azzopardi, P., Baldwin, W., Bonell, C., Kakuma, R., Kennedy, E., Mahon, J., McGovern, T., Mokdad, A. H., Patel, V., Petroni, S., Reavley, N., Taiwo, K., … Viner, R. M. (2016). Our future: a Lancet commission on adolescent health and wellbeing. *Lancet*, *387* (10036), 2423–2478. https://doi.org/10.1016/s0140-6736(16)00579-1

[2] Canavan, C. R., & Fawzi, W. W. (2019). Addressing knowledge gaps in adolescent nutrition: Toward advancing public health and sustainable development. *Current Developments in Nutrition*, *3* (7). https://doi.org/10.1093/cdn/nzz062

[3] Best, C., Neufingerl, N., van Geel, L., van den Briel, T., & Osendarp, S. (2010). The nutritional status of school-aged children: why should we care? *Food and Nutrition Bulletin*, *31* (3), 400–417. https://doi.org/10.1177/156482651003100303

[4] Di Cesare, M., Ghosh, S., Osendarp, S., Mozaffarian, D. (2021). A world free from malnutrition: An assessment of progress towards the global nutrition targets. In R. Micha (Ed.), Global Nutrition Report: The state of global nutrition (pp. 20–34). Global Nutrition Report. https://globalnutritionreport.org/documents/753/2021_Global_Nutrition_Report.pdf

[5] OCHA. (2016). *Briefing Note: Overview of El Niño Response in East and Southern Africa (as of 1 December 2016).* https://www.unocha.org/sites/unocha/files/2016ochaannualreport.pdf

[6] Dietz, W. H. (1998). Health consequences of obesity in youth: Childhood predictors of adult disease. *Pediatrics*, *101* (Supplement_2), 518-525. https://doi.org/10.1542/peds.101.s2.518

[7] UNICEF / WHO / World Bank Group Joint Child Malnutrition Estimates. (2019). Levels and trends in child malnutrition. Key findings of the 2019 edition. https://apps.who.int/iris/rest/bitstreams/1269729/retrieve

[8] World Health Organization. Regional Office for South-East Asia. (2006). Adolescent nutrition: a review of the situation in selected South-East Asian Countries. WHO Regional Office for South-East Asia. https://apps.who.int/iris/handle/10665/204764

[9] Amare, B., Moges, B., Fantahun, B., Tafess, K., Woldeyohannes, D., Yismaw, G., Ayane, T., Yabutani, T., Mulu, A., Ota, F., & Kassu, A. (2012). Micronutrient levels and nutritional status of school children living in northwest Ethiopia. *Nutrition Journal, 11* (1). https://doi.org/10.1186/1475-2891-11-108

[10] Arage, G., Assefa, M., & Worku, T. (2019). Socio-demographic and economic factors are associated with nutritional status of adolescent school girls in lay Guyint Woreda, northwest Ethiopia. *SAGE Open Medicine, 7*, 205031211984467. https://doi.org/10.1177/2050312119844679

[11] Tolesa Daba, K., Gessesse, G. W., & Bekele Sori, S. (1970). Proportion of glaucoma among voluntary people coming for glaucoma screening program at Jimma University Department of ophthalmology, Jimma, Ethiopia. *Ethiopian Journal of Health Sciences, 30* (1). https://doi.org/10.4314/ejhs.v30i1.3

[12] Dansa, R., Reta, F., Mulualem, D., Henry, C. J., & Whiting, S. J. (2019). A nutrition education intervention to increase consumption of pulses showed improved nutritional status of adolescent girls in Halaba special district, Southern Ethiopia. *Ecology of Food and Nutrition, 58* (4), 353-365. https://doi.org/10.1080/03670244.2019.1602042

[13] Hall, A., Kassa, T., Demissie, T., Degefie, T., & Lee, S. (2008). National survey of the health and nutrition of schoolchildren in Ethiopia. *Tropical Medicine & International Health: TM & IH, 13* (12), 1518–1526. https://doi.org/10.1111/j.1365-3156.2008.02168.x

[14] Ismail, A., Darling, A. M., Mosha, D., Fawzi, W., Sudfeld, C., Sando, M. M., Abdallah Noor, R., Charles, J., & Vuai, S. (2020). Prevalence and risk factors associated with malnutrition among adolescents in rural Tanzania. *Tropical Medicine & International Health: TM & IH, 25* (1), 89–100. https://doi.org/10.1111/tmi.13331

[15] Leenstra, T., Petersen, L. T., Kariuki, S. K., Oloo, A. J., Kager, P. A., & ter Kuile, F. O. (2005). Prevalence and severity of malnutrition and age at menarche; cross-sectional studies in adolescent schoolgirls in western Kenya. *European Journal of Clinical Nutrition, 59* (1), 41–48. https://doi.org/10.1038/sj.ejcn.1602031

[16] Manyanga, T., El-Sayed, H., Doku, D. T., & Randall, J. R. (2014). The prevalence of underweight, overweight, obesity and associated risk factors among school-going adolescents in seven African countries. *BMC Public Health, 14* (1), 887. https://doi.org/10.1186/1471-2458-14-887

[17] Melaku, Y. A., Zello, G. A., Gill, T. K., Adams, R. J., & Shi, Z. (2015). Prevalence and factors associated with stunting and thinness among adolescent students in Northern Ethiopia: a comparison to World Health Organization standards. *Archives Belges de Sante Publique [Archives of Public Health], 73* (1), 44. https://doi.org/10.1186/s13690-015-0093-9

[18] Motswagole, B., Kruger, H., Faber, M., Monyeki, K. (2012). Motswagole, B., Senior Nut, Kruger, H., Professor, Faber, M., Senior Spe, & Monyeki, K., Specialist. (2012). Body composition in stunted, compared to non-stunted, black South African children, from two rural communities. *The South African Journal of Clinical Nutrition: SAJCN: The Official Journal of the South African Society of Parenteral and Enteral Nutrition and the Association for Dietetics in South Africa, 25* (2), 62–66. https://doi.org/10.1080/16070658.2012.11734407

[19] Pradeilles, R., Griffiths, P. L., Norris, S. A., Feeley, A. B., & Rousham, E. K. (2015). Socio-economic influences on anthropometric status in urban South African adolescents: sex differences in the Birth to Twenty Plus cohort. *Public Health Nutrition, 18* (16), 2998–3012. https://doi.org/10.1017/S1368980015000415

[20] Regasa, R. T., & Haidar, J. A. (2019). Anemia and its determinant of in-school adolescent girls from rural Ethiopia: a school based cross-sectional study. *BMC Women's Health, 19* (1), 98. https://doi.org/10.1186/s12905-019-0791-5

[21] Seyoum, Y., Humblot, C., Nicolas, G., Thomas, M., & Baye, K. (2019). Iron deficiency and anemia in adolescent girls consuming predominantly plant-based diets in rural Ethiopia. *Scientific Reports, 9* (1), 17244. https://doi.org/10.1038/s41598-019-53836-5

[22] Teji, K., Dessie, Y., Assebe, T., & Abdo, M. (2016). Anaemia and nutritional status of adolescent girls in Babile District, Eastern Ethiopia. *The Pan African Medical Journal, 24*, 62. https://doi.org/10.11604/pamj.2016.24.62.6949

[23] Gebregyorgis, T., Tadesse, T., & Atenafu, A. (2016). Prevalence of thinness and stunting and associated factors among adolescent school girls in Adwa town, north Ethiopia. *International Journal of Food Science, 2016*, 8323982. https://doi.org/10.1155/2016/8323982

[24] Zemene, M. A., Engidaw, M. T., Gebremariam, A. D., Asnakew, D. T., & Tiruneh, S. A. (2019). Nutritional status and associated factors among high school adolescents in Debre Tabor Town, South Gondar Zone, Northcentral Ethiopia. *BMC Nutrition, 5* (1), 43. https://doi.org/10.1186/s40795-019-0306-7

[25] Acham, H., Kikafunda, J., Malde, M., Oldewage-Theron, W., & Egal, A. (2012). Breakfast, midday meals and academic achievement in rural primary schools in Uganda: Implications for education and school health policy. *Food & Nutrition Research, 56* (1), 11217. https://doi.org/10.3402/fnr.v56i0.11217

[26] Aiga, H., Abe, K., Andrianome, V. N., Randriamampionona, E., Razafinombana, A. R., Murai, T., & Hara, M. (2019). Risk factors for malnutrition among school-aged children: A cross-sectional study in rural Madagascar. *BMC Public Health, 19* (1). https://doi.org/10.1186/s12889-019-7013-9

[27] Birru, S. M., Tariku, A., & Belew, A. K. (2018). Improved dietary diversity of school adolescent girls in the context of urban northwest Ethiopia: 2017. *Italian Journal of Pediatrics, 44* (1). https://doi.org/10.1186/s13052-018-0490-0

[28] Belay, E., Handebo, S., Derso, T., Tariku, A., & Sisay, M. (2019). Prevalence and determinants of pre-adolescent (5–14 years) acute and chronic undernutrition in lay Armachiho district, Ethiopia. *International Journal for Equity in Health, 18* (1). https://doi.org/10.1186/s12939-019-1041-z

[29] Chesire, E., Orago, A., Oteba, L., & Echoka, E. (2009). Determinants of under nutrition among school age children in a Nairobi Peri-urban slum. *East African Medical Journal, 85* (10). https://doi.org/10.4314/eamj.v85i10.9671

[30] Manyanga, T. (2020). Examining lifestyle behaviours and weight status of primary schoolchildren: using Mozambique to explore the data gaps in low- and middle-income countries. *Applied Physiology Nutrition and Metabolism, 45* (2), 220. https://doi.org/10.1139/apnm-2019-0863

[31] Turyashemererwa, F. M., Kikafunda, J., Annan, R., & Tumuhimbise, G. A. (2013). Dietary patterns, anthropometric status, prevalence and risk factors for anaemia among school children aged 5-11 years in Central Uganda. Journal of Human Nutrition and Dietetics: *The Official Journal of the British Dietetic*

*Association, 26* Suppl 1, 73–81. https://doi.org/10.1111/jhn.12069

[32] Meko, LNM., Slabber-Stretch, M., Walsh, CM., Kruger, SH., Nel, M. (2015). Meko, L. N. M., Slabber-Stretch, M., Walsh, C. M., Kruger, S. H., & Nel, M. (2015). School environment, socioeconomic status and weight of children in Bloemfontein, South Africa. *African Journal of Primary Health Care & Family Medicine, 7* (1). https://doi.org/10.4102/phcfm.v7i1.751

[33] Mushonga, N., Kujinga, P., Chagwena, D., & Nyabanga, G. (2014). A restrospective study of the nutritional status of primary school children in Harare. *African Journal of Food, Agriculture, Nutrition and Development, 14* (63), 8837-8847. https://doi.org/10.18697/ajfand.63.13360

[34] Wolde, T., & Belachew, T. (2019). Predictors of thinness and improved dietary diversity among school aged children in southern Ethiopia. *Nutrition and Dietary Supplements, 11*, 49-58. https://doi.org/10.2147/nds.s221739

[35] Berg, T., Magala-Nyago, C., & Iversen, P. O. (2018). Nutritional status among adolescent girls in children's homes: Anthropometry and dietary patterns. *Clinical Nutrition, 37* (3), 926-933. https://doi.org/10.1016/j.clnu.2017.03.020

[36] Comandini, O., Carmignani, G., Cipriano, A., Carmignani, G., Tiba, D., & Marini, E. (2018). Cross-sectional and longitudinal analysis of nutritional status of school-children from Bumbire island (United Republic of Tanzania). *American Journal of Human Biology, 30* (3), e23098. https://doi.org/10.1002/ajhb.23098

[37] Renso, A. A., Dessie, Y., Berhane, Y., Assefa, N., Canavan, C. R., & Fawzi, W. W. (2020). Prevalence and predictors of adolescent linear growth and stunting across the urban-rural gradient in eastern Ethiopia. *Tropical Medicine & International Health: TM & IH, 25* (1), 101–110. https://doi.org/10.1111/tmi.13341

[38] Kruger, H. S., Pretorius, R., & Schutte, A. E. (2010). Stunting, adiposity, and low-grade inflammation in African adolescents from a township high school. *Nutrition (Burbank, Los Angeles County, Calif.), 26* (1), 90–99. https://doi.org/10.1016/j.nut.2009.10.004

[39] Wrottesley, S. V., Pedro, T. M., Fall, C. H., & Norris, S. A. (2020). A review of adolescent nutrition in South Africa: transforming adolescent lives through nutrition initiative. The South African Journal of Clinical Nutrition: SAJCN: The Official Journal of the South African Society of Parenteral and Enteral Nutrition and the Association for Dietetics in South Africa, 33 (4), 94–132. https://doi.org/10.1080/16070658.2019.1607481

[40] Demilew, Y. M., & Emiru, A. A. (2018). Under nutrition and associated factors among school adolescents in Dangila Town, Northwest Ethiopia: a cross sectional study. *African Health Sciences, 18* (3), 756–766. https://doi.org/10.4314/ahs.v18i3.34

[41] Alelign, T., Degarege, A., & Erko, B. (2015). Prevalence and factors associated with undernutrition and anaemia among school children in Durbete town, northwest Ethiopia. *Archives of Public Health, 73* (1). https://doi.org/10.1186/s13690-015-0084-x

[42] Bogale, T. Y., Bala, E. T., Tadesse, M., & Asamoah, B. O. (2018). Prevalence and associated factors for stunting among 6–12 years old school age children from rural community of Humbo district, Southern Ethiopia. *BMC Public Health, 18* (1). https://doi.org/10.1186/s12889-018-5561-z

[43] Darling, A. M., Sunguya, B., Ismail, A., Manu, A., Canavan, C., Assefa, N., Sie, A., Fawzi, W., Sudfeld, C., & Guwattude, D. (2019). Gender differences in nutritional status, diet and physical activity among adolescents in eight countries in sub-saharan Africa. *Tropical Medicine & International Health, 25* (1), 33-43. https://doi.org/10.1111/tmi.13330

[44] Talsma, E. F., Melse-Boonstra, A., de Kok, B. P. H., Mbera, G. N. K., Mwangi, A. M., & Brouwer, I. D. (2013). Biofortified cassava with pro-vitamin A is sensory and culturally acceptable for consumption by primary school children in Kenya. *PloS One, 8* (8), e73433. https://doi.org/10.1371/journal.pone.0073433

[45] Tathiah, N., Moodley, I., Mubaiwa, V., Denny, L., & Taylor, M. (2013). South Africa's nutritional transition: overweight, obesity, underweight and stunting in female primary school learners in rural KwaZulu-Natal, South Africa. *South African Medical Journal, 103* (10), 718–723. https://doi.org/10.7196/samj.6922

[46] Degarege, D., Degarege, A., & Animut, A. (2015). Undernutrition and associated risk factors among school age children in Addis Ababa, Ethiopia. *BMC Public Health, 15* (1), 375. https://doi.org/10.1186/s12889-015-1714-5

[47] Wei, D., Brigell, R., Khadka, A., Perales, N., & Fink, G. (2019). Comprehensive school-based health programs to improve child and adolescent health: Evidence from Zambia. *PloS One, 14* (5), e0217893. https://doi.org/10.1371/journal.pone.0217893

[48] Mphekgwana, P. M., Makgopa, H. M., Monyeki, K. D., Malatji, J. M., & Mabila, T. E. (2019). Ellisras Longitudinal Study 2017: Childhood underweight and blood pressure status in a rural black population of

South Africa (ELS 26). *Cardiovascular Journal of Africa, 30* (3), 146–150. https://doi.org/10.5830/CVJA-2018-061

[49] dos Santos, F. K., Maia, J. A. R., Gomes, T. N. Q. F., Daca, T., Madeira, A., Katzmarzyk, P. T., & Prista, A. (2014). Secular trends in growth and nutritional status of Mozambican school-aged children and adolescents. *PloS One, 9* (12), e114068. https://doi.org/10.1371/journal.pone.0114068

[50] Wakayo, T., Belachew, T., Vatanparast, H., & Whiting, S. J. (2015). Vitamin D deficiency and its predictors in a country with thirteen months of sunshine: The case of school children in central Ethiopia. *PloS One, 10* (3), e0120963. https://doi.org/10.1371/journal.pone.0120963

[51] Adom, T., Kengne, A. P., De Villiers, A., & Puoane, T. (2019). Prevalence of overweight and obesity among African primary school learners: a systematic review and meta-analysis: Meta-analysis of overweight and obesity prevalence in African learners. *Obesity Science & Practice, 5* (5), 487–502. https://doi.org/10.1002/osp4.355

[52] Anteneh, Z. A., Gedefaw, M., Tekletsadek, K. N., Tsegaye, M., & Alemu, D. (2015). Risk factors of overweight and obesity among high school students in Bahir Dar city, north west Ethiopia: School based cross-sectional study. *Advances in Preventive Medicine, 2015*, 294902. https://doi.org/10.1155/2015/294902

[53] Bonney, E., Ferguson, G., & Smits-Engelsman, B. (2018). Relationship between body mass index, cardiorespiratory and musculoskeletal fitness among South African adolescent girls. *International Journal of Environmental Research and Public Health, 15* (6). https://doi.org/10.3390/ijerph15061087

[54] Chomba, H., Martin, H. D., & Kimywe, J. (2019). Prevalence and predictors of obesity among 7- to 17-year-old schoolchildren in urban Arusha, Tanzania. *Journal of Nutrition and Metabolism, 2019*, 3106597. https://doi.org/10.1155/2019/3106597

[55] Choukem, S.-P., Tochie, J. N., Sibetcheu, A. T., Nansseu, J. R., & Hamilton-Shield, J. P. (2020). Overweight/obesity and associated cardiovascular risk factors in sub-Saharan African children and adolescents: a scoping review. *International Journal of Pediatric Endocrinology, 2020* (1), 6. https://doi.org/10.1186/s13633-020-0076-7

[56] Craig, E., Bland, R., & Reilly, J. (2013). Objectively measured physical activity levels of children and adolescents in rural South Africa: High volume of physical activity at low intensity. *Applied Physiology Nutrition and Metabolism, 38* (1), 81–84. https://doi.org/10.1139/apnm-2012-0115

[57] Desalew, A., Mandesh, A., & Semahegn, A. (2017). Childhood overweight, obesity and associated factors among primary school children in dire dawa, Eastern Ethiopia; a cross-sectional study. *BMC Obesity, 4* (1). https://doi.org/10.1186/s40608-017-0156-2

[58] Idamokoro, M., Goon, D. T., & Lyoka, P. (2019). Anthropometric and motor development characteristics of rural children in Nkonkobe Municipality, South Africa. Medicina Dello Sport; Rivista Di Fisiopatologia *Dello Sport, 72* (1). https://doi.org/10.23736/s0025-7826.18.03419-1

[59] Maradzika, J., Ministry of Health and Child Care, Chapoterera, B., Marume, A., Zikiti, A., & University of Zimbabwe, Zimbabwe. (2017). Determinants of dietary patterns and obesity among secondary school adolescents in Harare, Zimbabwe, 2016. *International Journal of Child Health and Nutrition, 6* (4), 144–158. https://doi.org/10.6000/1929-4247.2017.06.04.4

[60] Mpembeni, R. N. M., Muhihi, A. J., Maghembe, M., Ngarashi, D., Lujani, B., Chillo, O., Kubhoja, S., Anaeli, A., & Njelekela, M. A. (2014). Overweight, obesity and perceptions about body weight among primary schoolchildren in Dar es Salaam, Tanzania. *Tanzania Journal of Health Research, 16* (4), 304–311. https://doi.org/10.4314/thrb.v16i4.7

[61] Muthuri, S. K., Wachira, L.-J. M., Onywera, V. O., & Tremblay, M. S. (2014). Correlates of objectively measured overweight/obesity and physical activity in Kenyan school children: results from ISCOLE-Kenya. *BMC Public Health, 14* (1), 436. https://doi.org/10.1186/1471-2458-14-436

[62] Mwaikambo, S. A., Leyna, G. H., Killewo, J., Simba, A., & Puoane, T. (2015). Why are primary school children overweight and obese? A cross sectional study undertaken in Kinondoni district, Dar-es-salaam. *BMC Public Health, 15* (1), 1269. https://doi.org/10.1186/s12889-015-2598-0

[63] Ngwenya, NA., Ramukumba, TS. (2017). Ngwenya, N. A., & Ramukumba, T. S. (2017). Prevalence of adolescent obesity at a high school in the City of Tshwane. *Curationis, 40* (1), e1–e7. https://doi.org/10.4102/curationis.v40i1.1662

[64] Nicholaus, C., Martin, H. D., Kassim, N., Matemu, A. O., & Kimiywe, J. (2020). Dietary practices, nutrient adequacy, and nutrition status among adolescents in boarding high schools in the Kilimanjaro region,

Tanzania. *Journal of Nutrition and Metabolism, 2020*, 3592813. https://doi.org/10.1155/2020/3592813

[65] Otitoola, O., Oldewage-Theron, W., & Egal, A. (2021). Prevalence of overweight and obesity among selected schoolchildren and adolescents in Cofimvaba, South Africa. *The South African Journal of Clinical Nutrition: SAJCN: The Official Journal of the South African Society of Parenteral and Enteral Nutrition and the Association for Dietetics in South Africa, 34* (3), 97–102. https://doi.org/10.1080/16070658.2020.1733305

[66] Pangani, I. N., Kiplamai, F. K., Kamau, J. W., & Onywera, V. O. (2016). Prevalence of overweight and obesity among primary school children aged 8-13 years in Dar es Salaam city, Tanzania. *Advances in Preventive Medicine, 2016*, 1345017. https://doi.org/10.1155/2016/1345017

[67] Pienaar, A. E. (2015). Prevalence of overweight and obesity among primary school children in a developing country: NW-CHILD longitudinal data of 6-9-yr-old children in South Africa. *BMC Obesity, 2* (1), 2. https://doi.org/10.1186/s40608-014-0030-4

[68] Mekonnen, T., Tariku, A., & Abebe, S. M. (2018). Overweight/obesity among school aged children in Bahir Dar City: cross sectional study. *Italian Journal of Pediatrics, 44* (1), 17. https://doi.org/10.1186/s13052-018-0452-6

[69] Taklual, W., Baye, S., Mekie, M., & Andualem, T. (2020). Double burden of malnutrition among female adolescent students in Bahir Dar City, Amhara, Ethiopia. *BioMed Research International, 2020*, 6249524. https://doi.org/10.1155/2020/6249524

[70] Korkalo, L., Freese, R., Alfthan, G., Fidalgo, L., & Mutanen, M. (2015). Poor micronutrient intake and status is a public health problem among adolescent Mozambican girls. *Nutrition Research (New York, N.Y.), 35* (8), 664–673. https://doi.org/10.1016/j.nutres.2015.05.013

[71] Napier, C., & Oldewage-Theron, W. (2015). Dietary intake and nutritional status of adolescent girls and young women in Durban, South Africa. *Journal of Consumer Sciences. 43* (1), 1-15.

[72] Chirwa, E. D., Griffiths, P., Maleta, K., Ashorn, P., Pettifor, J. M., & Norris, S. A. (2014). Postnatal growth velocity and overweight in early adolescents: a comparison of rural and urban African boys and girls: Postnatal growth and obesity in early adolescents. *American Journal of Human Biology: The Official Journal of the Human Biology Council, 26* (5), 643–651. https://doi.org/10.1002/ajhb.22575

[73] Jinabhai, C. C., Reddy, P., Taylor, M., Monyeki, D., Kamabaran, N., Omardien, R., & Sullivan, K. R. (2007). Sex differences in under and over nutrition among school-going Black teenagers in South Africa: an uneven nutrition trajectory: Sex differences in nutritional status among South Africa. *Tropical Medicine & International Health: TM & IH, 12* (8), 944–952. https://doi.org/10.1111/j.1365-3156.2007.01861.x

[74] Monyeki, M. A., Neetens, R., Moss, S. J., & Twisk, J. (2012). The relationship between body composition and physical fitness in 14 year old adolescents residing within the Tlokwe local municipality, South Africa: the PAHL study. *BMC Public Health, 12* (1), 374. https://doi.org/10.1186/1471-2458-12-374

[75] Ohnishi, M., Leshabari, S., Ambikile, J. S., Oishi, K., Nakao, Y., & Nishihara, M. (2017). Associations among anthropometric measures, food consumption, and quality of life in school-age children in Tanzania. *Journal of Rural Medicine, 12* (1), 38–45. https://doi.org/10.2185/jrm.2924

[76] Toriola, O. O., Monyeki, M. A., & Toriola, A. L. (2015). Two-year longitudinal health-related fitness, anthropometry and body composition status amongst adolescents in Tlokwe Municipality: The PAHL Study. *African Journal of Primary Health Care & Family Medicine, 7* (1), 896. https://doi.org/10.4102/phcfm.v7i1.896

[77] Armstrong, M. E. G., Lambert, M. I., & Lambert, E. V. (2017). Relationships between different nutritional anthropometric statuses and health-related fitness of South African primary school children. *Annals of Human Biology, 44* (3), 208–213. https://doi.org/10.1080/03014460.2016.1224386

[78] Fall, C. H., Abera, M., Chopra, H., Hardy-Johnson, P., Janha, R. E., Jesson, J., Joglekar, C., Joseph, S., Kehoe, S. H., Mukoma, G., Joshi-Reddy, K., Kumaran, K., Barker, M. E., & TALENT consortium. (2021). Anthropometric nutritional status, and social and dietary characteristics of African and Indian adolescents taking part in the TALENT (Transforming Adolescent Lives through Nutrition) qualitative study. *Public Health Nutrition, 24* (16), 5249–5260. https://doi.org/10.1017/S1368980020001901

[79] Ginsburg, C., Griffiths, P. L., Richter, L. M., & Norris, S. A. (2013). Residential mobility, socioeconomic context and body mass index in a cohort of urban South African adolescents. *Health & Place, 19*, 99–107. https://doi.org/10.1016/j.healthplace.2012.09.016

[80] Hassen, K., Gizaw, G., & Belachew, T. (2017). Dual burden of malnutrition among adolescents of smallholder coffee farming households of Jimma Zone, southwest

Ethiopia. *Food and Nutrition Bulletin, 38* (2), 196–208. https://doi.org/10.1177/0379572117701660

[81] Kimani-Murage, E. W., Kahn, K., Pettifor, J. M., Tollman, S. M., Dunger, D. B., Gómez-Olivé, X. F., & Norris, S. A. (2010). The prevalence of stunting, overweight and obesity, and metabolic disease risk in rural South African children. *BMC Public Health, 10* (1), 158. https://doi.org/10.1186/1471-2458-10-158

[82] Kruger, R., Kruger, H. S., & Macintyre, U. E. (2006). The determinants of overweight and obesity among 10- to 15-year-old schoolchildren in the North West Province, South Africa - the THUSA BANA (Transition and Health during Urbanisation of South Africans; BANA, children) study. *Public Health Nutrition, 9* (3), 351–358. https://doi.org/10.1079/phn2006849

[83] Mamabolo, R. L., Kruger, H. S., Lennox, A., Monyeki, M. A., Pienaar, A. E., Underhay, C., & Czlapka-Matyasik, M. (2007). Habitual physical activity and body composition of black township adolescents residing in the North West Province, South Africa. *Public Health Nutrition, 10* (10), 1047–1056. https://doi.org/10.1017/S1368980007668724

[84] Negash, S., Agyemang, C., Matsha, T. E., Peer, N., Erasmus, R. T., & Kengne, A. P. (2017). Differential prevalence and associations of overweight and obesity by gender and population group among school learners in South Africa: a cross-sectional study. *BMC Obesity, 4* (1), 29. https://doi.org/10.1186/s40608-017-0165-1

[85] Silva, A. B., Capingana, D. P., Magalhães, P., Gonçalves, M. A., Molina, M. D. C. B., Rodrigues, S. L., Baldo, M. P., Mateus, M. S., & Mill, J. G. (2016). Cardiovascular risk factors in pre-pubertal schoolchildren in Angola. *Cardiovascular Journal of Africa, 27* (5), 315–321. https://doi.org/10.5830/CVJA-2016-029

[86] Teferi, D. Y., Atomssa, G. E., & Mekonnen, T. C. (2018). Overweight and undernutrition in the cases of school-going adolescents in Wolaita Sodo town, Southern Ethiopia: Cross-sectional study. *Journal of Nutrition and Metabolism, 2018*, 1–10. https://doi.org/10.1155/2018/8678561

[87] van den Berg, V. L., Seheri, L., & Raubenheimer, J. (2014). Body mass index of 16-year-olds in urban Maseru, Lesotho. *African Journal of Primary Health Care & Family Medicine, 6* (1), E1–E14. https://doi.org/10.4102/phcfm.v6i1.618

[88] Tluway, F. D., Leyna, G. H., & Mmbaga, E. J. (2018). Magnitude and factors associated with overweight and obesity among adolescents in in semi-rural area of Babati District, Tanzania. *Tanzania Journal of Health Research, 20* (2). https://doi.org/10.4314/thrb.v20i2.2

[89] Gali, N., Tamiru, D., & Tamrat, M. (2017). The emerging nutritional problems of school adolescents: Overweight/obesity and associated factors in Jimma town, Ethiopia. *Journal of Pediatric Nursing, 35*, 98–104. https://doi.org/10.1016/j.pedn.2017.03.002

[90] Okeyo, A. P., Seekoe, E., de Villiers, A., Faber, M., Nel, J. H., & Steyn, N. P. (2020). Dietary practices and adolescent obesity in secondary school learners at disadvantaged schools in South Africa: Urban-rural and gender differences. *International Journal of Environmental Research and Public Health, 17* (16), 5864. https://doi.org/10.3390/ijerph17165864

[91] Craig, E., Reilly, J. J., & Bland, R. (2016). Risk factors for overweight and overfatness in rural South African children and adolescents. *Journal of Public Health (Oxford, England), 38* (1), 24–33. https://doi.org/10.1093/pubmed/fdv016

[92] Danquah, F. I., Ansu-Mensah, M., Bawontuo, V., Yeboah, M., Udoh, R. H., Tahiru, M., & Kuupiel, D. (2020). Risk factors and morbidities associated with childhood obesity in sub-Saharan Africa: a systematic scoping review. *BMC Nutrition, 6* (1), 37. https://doi.org/10.1186/s40795-020-00364-5

[93] Harika, R., Faber, M., Samuel, F., Mulugeta, A., Kimiywe, J., & Eilander, A. (2017). Are low intakes and deficiencies in iron, vitamin A, zinc, and iodine of public health concern in Ethiopian, Kenyan, Nigerian, and south African children and adolescents? *Food and Nutrition Bulletin, 38* (3), 405–427. https://doi.org/10.1177/0379572117715818

[94] Barugahara, E., Kikafunda, J., & Gakenia, W. (2013). Prevalence and risk factors of nutritional anaemia among female school children in Masindi district, western Uganda. *African Journal of Food, Agriculture, Nutrition and Development, 13* (58), 7679-7692. https://doi.org/10.18697/ajfand.58.11930

[95] Parker, M. E., Mosites, E., Reider, K., Ndayishimiye, N., Waring, M., Nyandimbane, G., Masumbuko, D., Ndikuriyo, L., & Matthias, D. (2015). A blinded, cluster-randomized, placebo-controlled school FeedingTrial in Burundi using rice fortified with iron, zinc, thiamine, and folic acid. *Food and Nutrition Bulletin, 36* (4), 481-492. https://doi.org/10.1177/0379572115615234

[96] Woodruff, B. A., Blanck, H. M., Slutsker, L., Cookson, S. T., Larson, M. K., Duffield, A., & Bhatia, R. (2006). Anaemia, iron status and vitamin A deficiency among

adolescent refugees in Kenya and Nepal. *Public Health Nutrition, 9* (1), 26–34. https://doi.org/10.1079/phn2005825

[97] Gwetu, T. P., Chhagan, M. K., Taylor, M., Kauchali, S., & Craib, M. (2017). Anaemia control and the interpretation of biochemical tests for iron status in children. *BMC Research Notes, 10* (1). https://doi.org/10.1186/s13104-017-2472-5

[98] Seal, A., Kafwembe, E., Kassim, I. A. R., Hong, M., Wesley, A., Wood, J., Abdalla, F., & van den Briel, T. (2008). Maize meal fortification is associated with improved vitamin A and iron status in adolescents and reduced childhood anaemia in a food aid-dependent refugee population. *Public Health Nutrition, 11* (7), 720–728. https://doi.org/10.1017/S1368980007001486

[99] van der Hoeven, M., Faber, M., Osei, J., Kruger, A., & Smuts, C. M. (2016). Effect of African leafy vegetables on the micronutrient status of mildly deficient farm-school children in South Africa: a randomized controlled study. *Public Health Nutrition, 19*(5), 935–945. https://doi.org/10.1017/S1368980015002037

[100] Visser, M., Van Zyl, T., Hanekom, S. M., Baumgartner, J., van der Hoeven, M., Taljaard-Krugell, C., Smuts, C. M., & Faber, M. (2019). Nutrient patterns and their relation to anemia and iron status in 5- to 12-y-old children in South Africa. *Nutrition (Burbank, Los Angeles County, Calif.), 62*, 194–200. https://doi.org/10.1016/j.nut.2019.01.016

[101] Gwetu, T. P., Taylor, M., Chhagan, M., Kauchali, S., & Craib, M. (2019). Health and educational achievement of school-aged children: The impact of anaemia and iron status on learning. *Health SA Gesondheid, 24*, 1101. https://doi.org/10.4102/hsag.v24i0.1101

[102] Tatala, S. R., Kihamia, C. M., Kyungu, L. H., & Svanberg, U. (2008). Risk factors for anaemia in schoolchildren in Tanga Region, Tanzania. *Tanzania Journal of Health Research, 10* (4), 189–202. https://doi.org/10.4314/thrb.v10i4.45074

[103] Birhanu, M., Gedefaw, L., & Asres, Y. (2018). Anemia among school-age children: Magnitude, severity and associated factors in Pawe town, benishangul-gumuz region, northwest Ethiopia. *Ethiopian Journal of Health Sciences, 28* (3), 259. https://doi.org/10.4314/ejhs.v28i3.3

[104] Desalegn Wolide, A., Mossie, A., & Gedefaw, L. (2018). Correction: Nutritional iron deficiency anemia: Magnitude and its predictors among school age children, southwest Ethiopia: A community based cross-sectional study. *PloS One, 13* (8), e0202380. https://doi.org/10.1371/journal.pone.0202380

[105] Gonete, K. A., Tariku, A., Wami, S. D., & Derso, T. (2018). Prevalence and associated factors of anemia among adolescent girls attending high schools in Dembia District, Northwest Ethiopia, 2017. *Archives Belges de Sante Publique [Archives of Public Health], 76* (1), 79. https://doi.org/10.1186/s13690-018-0324-y

[106] Shaka, M. F., & Wondimagegne, Y. A. (2018). Anemia, a moderate public health concern among adolescents in south Ethiopia. *PloS One, 13* (7), e0191467. https://doi.org/10.1371/journal.pone.0191467

[107] Getaneh, Z., Enawgaw, B., Engidaye, G., Seyoum, M., Berhane, M., Abebe, Z., Asrie, F., & Melku, M. (2017). Prevalence of anemia and associated factors among school children in Gondar town public primary schools, northwest Ethiopia: A school-based cross-sectional study. *PloS One, 12* (12), e0190151. https://doi.org/10.1371/journal.pone.0190151

[108] Damane Sebotsa, M. L., Dannhauser, A., Jooste, P. L., & Joubert, G. (2005). Iodine content of salt 2 years after the introduction of the universal salt iodisation legislation in Lesotho. *British Journal of Nutrition, 93* (6), 917-922. https://doi.org/10.1079/bjn20041314

[109] Horjus, P., Aguayo, V. M., Roley, J. A., Pene, M. C., & Meershoek, S. P. (2005). School-based iron and folic acid supplementation for adolescent girls: findings from Manica Province, Mozambique. *Food and Nutrition Bulletin, 26* (3), 281–286. https://doi.org/10.1177/156482650502600305

[110] Hassen, H. Y., Beyene, M., & Ali, J. H. (2019). Dietary pattern and its association with iodine deficiency among school children in southwest Ethiopia; A cross-sectional study. *PloS One, 14*(8), e0221106. https://doi.org/10.1371/journal.pone.0221106

[111] Harika, R., Faber, M., Samuel, F., Kimiywe, J., Mulugeta, A., & Eilander, A. (2017). Micronutrient status and dietary intake of iron, vitamin A, iodine, folate and zinc in women of reproductive age and pregnant women in Ethiopia, Kenya, Nigeria and South Africa: A systematic review of data from 2005 to 2015. *Nutrients, 9* (10), 1096. https://doi.org/10.3390/nu9101096

[112] Hailu, S., Wubshet, M., Woldie, H., & Tariku, A. (2016). Iodine deficiency and associated factors among school children: a cross-sectional study in Ethiopia. *Archives Belges de Sante Publique [Archives of Public Health], 74* (1), 46. https://doi.org/10.1186/s13690-016-0158-4

[113] Girma, K., Nibret, E., & Gedefaw, M. (2014). The status of iodine nutrition and iodine deficiency disorders among school children in Metekel Zone, northwest Ethiopia. *Ethiopian Journal of Health Sciences, 24* (2), 109–116. https://doi.org/10.4314/ejhs.v24i2.2

[114] Muktar, M., Roba, K. T., Mengistie, B., & Gebremichael, B. (2018). Iodine deficiency and its associated factors among primary school children in Anchar district, Eastern Ethiopia. *Pediatric Health, Medicine and Therapeutics, 9*, 89–95. https://doi.org/10.2147/PHMT.S165933

[115] Assey, V. D., Mgoba, C., Mlingi, N., Sanga, A., Ndossi, G. D., Greiner, T., & Peterson, S. (2007). Remaining challenges in Tanzania's efforts to eliminate iodine deficiency. *Public Health Nutrition, 10* (10), 1032-1038. https://doi.org/10.1017/s1368980007666695

[116] Poopedi, M. A., Norris, S. A., & Pettifor, J. M. (2011). Factors influencing the vitamin D status of 10-year-old urban South African children. *Public Health Nutrition, 14* (2), 334–339. https://doi.org/10.1017/S136898001000234X

[117] White, Z., White, S., Dalvie, T., Kruger, M. C., Van Zyl, A., & Becker, P. (2019). Bone health, body composition, and vitamin D status of black preadolescent children in South Africa. *Nutrients, 11* (6), 1243. https://doi.org/10.3390/nu11061243

[118] Megersa, D. G., Mekonnen Abebe, S., Abebe, F., & Wassie, M. M. (2017). Prevalence and associated factors of low serum zinc concentration in adolescents of Gambella city, Southwest Ethiopia. *Nutrition and Dietary Supplements, 9*, 1-8. https://doi.org/10.2147/nds.s126755

[119] Samuel, F. O., Egal, A. A., Oldewage-Theron, W. H., Napier, C. E., & Venter, C. S. (2010). Prevalence of zinc deficiency among primary school children in a poor Peri-urban informal settlement in South Africa. *Health SA Gesondheid, 15* (1). https://doi.org/10.4102/hsag.v15i1.433

[120] Gonete, K. A., Tariku, A., Wami, S. D., & Akalu, T. Y. (2020). Dietary diversity practice and associated factors among adolescent girls in Dembia district, northwest Ethiopia, 2017. *Public Health Reviews, 41* (1), 23. https://doi.org/10.1186/s40985-020-00137-2

[121] Katungwe, P., Lilongwe University of Agriculture and Natural Resources (LUANAR),Malawi, Mwangwela, A., & Geresomo, N. (2015). Dietary adequacy of rural school children among bambara groundnut growing farmers in Ntchisi district of Malawi. *African Journal of Food Agriculture Nutrition and Development, 15* (68), 9620–9634. https://doi.org/10.18697/ajfand.68.13910

[122] Herrador, Z., Perez-Formigo, J., Sordo, L., Gadisa, E., Moreno, J., Benito, A., Aseffa, A., & Custodio, E. (2015). Low dietary diversity and intake of animal source foods among school aged children in Libo Kemkem and Fogera districts, Ethiopia. *PloS One, 10* (7), e0133435. https://doi.org/10.1371/journal.pone.0133435

[123] Isabirye, N., Bukenya, J. N., Nakafeero, M., Ssekamatte, T., Guwatudde, D., & Fawzi, W. (2020). Dietary diversity and associated factors among adolescents in eastern Uganda: a cross-sectional study. *BMC Public Health, 20* (1), 534. https://doi.org/10.1186/s12889-020-08669-7

[124] Belachew, T., Lindstrom, D., Gebremariam, A., Hogan, D., Lachat, C., Huybregts, L., & Kolsteren, P. (2013). Food insecurity, food based coping strategies and suboptimal dietary practices of adolescents in Jimma zone Southwest Ethiopia. *PloS One, 8* (3), e57643. https://doi.org/10.1371/journal.pone.0057643

[125] Voorend, C. G. N., Norris, S. A., Griffiths, P. L., Sedibe, M. H., Westerman, M. J., & Doak, C. M. (2013). "We eat together; today she buys, tomorrow I will buy the food": adolescent best friends' food choices and dietary practices in Soweto, South Africa. *Public Health Nutrition, 16* (3), 559–567. https://doi.org/10.1017/S1368980012003254

[126] Brown, C., Shaibu, S., Maruapula, S., Malete, L., & Compher, C. (2015). Perceptions and attitudes towards food choice in adolescents in Gaborone, Botswana. *Appetite, 95*, 29–35. https://doi.org/10.1016/j.appet.2015.06.018

[127] Hauta-Alus, H. H., Korkalo, L., Freese, R., Ismael, C., & Mutanen, M. (2018). Urban and rural dietary patterns are associated with anthropometric and biochemical indicators of nutritional status of adolescent Mozambican girls. *Public Health Nutrition, 21* (6), 1057–1064. https://doi.org/10.1017/S1368980017003676

[128] Kiwanuka, S. N., Astrøm, A. N., & Trovik, T. A. (2006). Sugar snack consumption in Ugandan schoolchildren: Validity and reliability of a food frequency questionnaire. *Community Dentistry and Oral Epidemiology, 34* (5), 372–380. https://doi.org/10.1111/j.1600-0528.2006.00287.x

[129] Feeley, A., Musenge, E., Pettifor, J. M., & Norris, S. A. (2012). Changes in dietary habits and eating practices in adolescents living in urban South Africa: the birth to twenty cohort. *Nutrition (Burbank, Los Angeles County, Calif.), 28* (7–8), e1-6. https://doi.org/10.1016/j.nut.2011.11.025

[130] Sedibe, H. M., Kahn, K., Edin, K., Gitau, T., Ivarsson, A., & Norris, S. A. (2014). Qualitative study exploring healthy eating practices and physical activity among adolescent girls in rural South Africa. *BMC Pediatrics,* 14, 211. https://doi.org/10.1186/1471-2431-14-211

[131] Temple, N. J., Steyn, N. P., Myburgh, N. G., & Nel, J. H. (2006). Food items consumed by students attending schools in different socioeconomic areas in Cape Town, South Africa. *Nutrition (Burbank, Los Angeles County, Calif.), 22* (3), 252–258. https://doi.org/10.1016/j.nut.2005.07.013

[132] Steyn, N. P., & McHiza, Z. J. (2014). Obesity and the nutrition transition in Sub-Saharan Africa: Obesity and the nutrition transition. *Annals of the New York Academy of Sciences, 1311* (1), 88–101. https://doi.org/10.1111/nyas.12433

[133] UNICEF. (2020). The state of the world's children 2019 The state of the world's children 2019: Children, food and nutrition - growing well in a changing world (United Nations Publications, Ed.). UNICEF.

[134] Keats, E. C., Das, J. K., Salam, R. A., Lassi, Z. S., Imdad, A., Black, R. E., & Bhutta, Z. A. (2021). Effective interventions to address maternal and child malnutrition: An update of the evidence. *The Lancet Child & Adolescent Health, 5* (5), 367-384. https://doi.org/10.1016/s2352-4642(20)30274-1

[135] World Health Organization. (2018). Guideline: implementing effective actions for improving adolescent nutrition. World Health Organization. https://apps.who.int/iris/handle/10665/260297 License: CC BY-NC-SA 3.0 IGO

[136] UNICEF. 2022. Early childbearing. Version current December 2022. Available at URL: https://data.unicef.org/topic/child-health/adolescent-health/

[137] Branca, F., Piwoz, E., Schultink, W., & Sullivan, L. M. (2015). Nutrition and health in women, children, and adolescent girls. *BMJ (Clinical Research Ed.), h4173*. https://doi.org/10.1136/bmj.h4173

[138] de Onis, M., Onyango, A. W., Borghi, E., Siyam, A., Nishida, C., & Siekmann, J. (2007). Development of a WHO growth reference for school-aged children and adolescents. *Bulletin of the World Health Organization, 85* (9), 660–667. https://doi.org/10.2471/blt.07.043497

[139] Wang, Y., & Wang, J. (2002). A comparison of international references for the assessment of child and adolescent overweight and obesity in different populations. *European Journal of Clinical Nutrition, 56* (10), 973-982. https://doi.org/10.1038/sj.ejcn.1601415

[140] Jane Scott, N. A. (2015). Childhood obesity estimates based on WHO and IOTF reference values. *Journal of Obesity & Weight Loss Therapy, 05* (01). https://doi.org/10.4172/2165-7904.1000249

[141] Mulugeta, A., Hagos, F., Stoecker, B., Kruseman, G., Linderhof, V., Abraha, Z., Yohannes, M., & Samuel, G. G. (2009). Nutritional status of adolescent girls from rural communities of Tigray, northern Ethiopia. *The Ethiopian Journal of Health Development, 23* (1). https://doi.org/10.4314/ejhd.v23i1.44831

[142] Hajian-Tilaki, K., & Heidari, B. (2013). A comparison between International Obesity Task Force and Center for Disease Control references in assessment of overweight and obesity among adolescents in Babol, northern Iran. *International Journal of Preventive Medicine, 4*(2), 226–232

[143] Li, K., Haynie, D., Palla, H., Lipsky, L., Iannotti, R. J., & Simons-Morton, B. (2016). Assessment of adolescent weight status: Similarities and differences between CDC, IOTF, and WHO references. *Preventive Medicine, 87*, 151–154. https://doi.org/10.1016/j.ypmed.2016.02.035

[144] Tariku, E. Z., Abebe, G. A., Melketsedik, Z. A., & Gutema, B. T. (2018). Prevalence and factors associated with stunting and thinness among school-age children in Arba Minch Health and Demographic Surveillance Site, Southern Ethiopia. *PloS One, 13* (11), e0206659. https://doi.org/10.1371/journal.pone.0206659

[145] Tariku, A., Belew, A. K., Gonete, K. A., Hunegnaw, M. T., Muhammad, E. A., Demissie, G. D., Biks, G. A., Awoke, T., Gelaye, K. A., Zeleke, E. G., Abebe, Z., Gete, A. A., Yesuf, M. E., Abebe, S. M., Gete, Y. K., Gelagay, A. A., Fekadu, A., Muchie, K. F., & Wassie, M. M. (2019). Stunting and its determinants among adolescent girls: Findings from the nutrition surveillance project, northwest Ethiopia. *Ecology of Food and Nutrition, 58* (5), 481–494. https://doi.org/10.1080/03670244.2019.1636793