2018 – 2023

# KaziAfya Project

*Well-being, health, and health-related behaviours in primary schoolchildren living in Tanzania*

University of Basel

NELSON MANDELA UNIVERSITY

Swiss TPH

fondation BOTNAR

***“Education is the most powerful weapon which you can use to change the world.”***

*Nelson Mandela*

KaziAfya

Schools for Active and Healthy Kidz

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# Contents

# Introduction

***Children's health depends on cultural, environmental, and socioeconomic factors as well as current living conditions and social community networks.***

## *1.1. Preface*

Ensuring healthy lives and promoting well-being among children is a complex and challenging endeavour. Indeed, children's health depends on cultural, environmental, and socioeconomic factors as well as current living conditions and social and community networks (Dahlgren & Whitehead, 1991). In low- and middle-income countries (LMICs), infectious diseases remain a key public health problem, which negatively impacts on children's physical and cognitive development (Murray et al., 2012). For example, more than 1 billion people are infected with parasitic worms (helminths) (Colley, Bustinduy, Secor, & King, 2014; Yap et al., 2014). Helminth infections can cause abdominal pain, diarrhoea, and anaemia, and might impair cognitive and physical development (Utzinger et al., 2012), resulting in reduced fitness and work productivity (Yap et al., 2012). Moreover, helminth infections can have a negative impact on children's nutritional status (Hürlimann et al., 2014). In summary, a deprived socio-economic environment can put children at risk of malnutrition and growth retardation. Malnutrition has been found to be associated with stunting and poor cognitive development resulting in low IQ, cognitive delays and problems with motor development. This, in turn, can cause problems with children's ability to concentrate, process information and focus on academic work. Children from low socio-economic status (SES) families are also less likely to have access to health care or health insurance and this leads to a greater risk of illness and school absence and consequently to poor academic performance. These deficiencies can prevent school-aged children from realising their full potential and perpetuate a vicious cycle of poverty and poor health.

Boys physical education class

***School-based physical activity interventions are worthwhile because a considerable number of children's daily activity is acquired during school hours.***

Additionally, non-communicable diseases (NCDs) are a rapidly growing public health problem and impose a considerable burden on population health (Marshall, 2004). New research has revealed that the African populations have moved towards a disease profile similar to Western countries, with increasing proportions of deaths attributed to chronic, lifestyle-related diseases (Steyn & Damasceno, 2006) and overweight, replacing undernutrition as a risk factor (Lim et al., 2012; Murray et al., 2012). Consequently, children are at an increased risk of compromised health due to a dual burden of diseases, which may hamper their development and well-being (Marshall, 2004; Santosa, Wall, Fottrell, Hogberg, & Byass, 2014). This dual burden constitutes a challenge for health systems in African countries. Although children are mainly affected by infectious diseases, they may at a young age already develop risk-factors predisposing them to NCDs in early adulthood (Alliance., 2016; Herman, Craig, Gauvin, & Katzmarzyk, 2009).

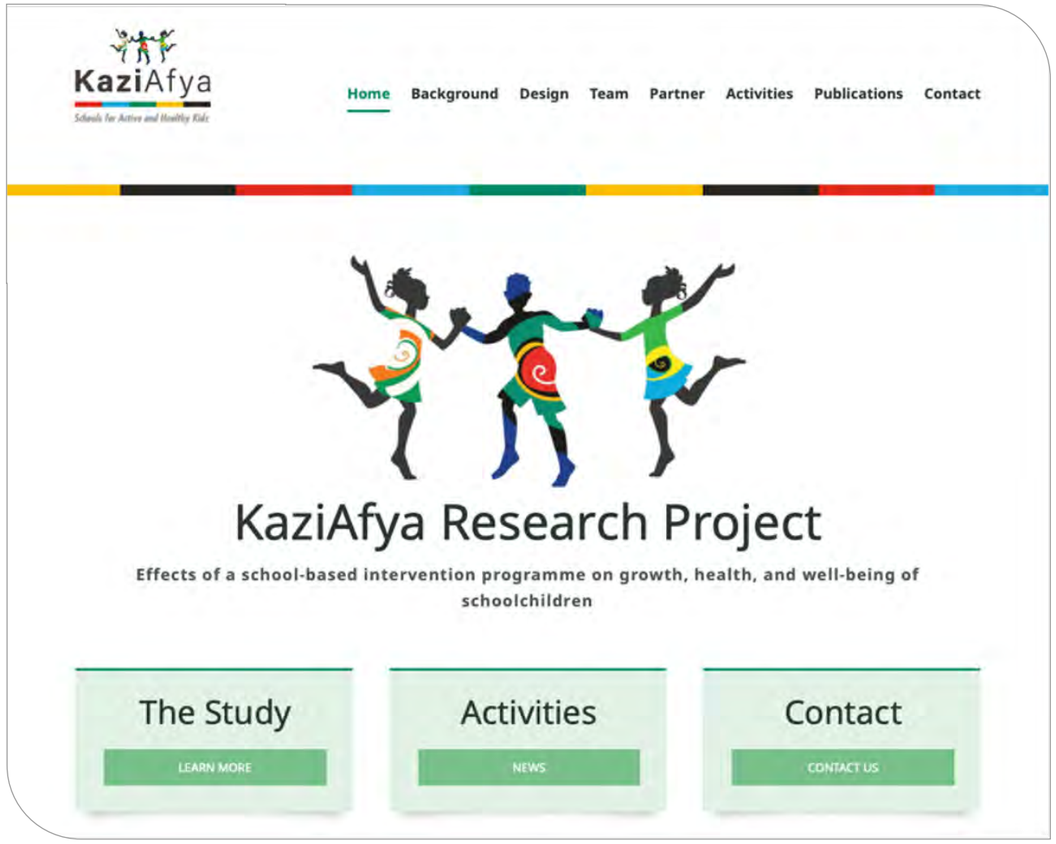
Given that (i) childhood physical inactivity is an independent risk factor for NCDs, which can lead to poor health outcomes in later life (Dwyer et al., 2009; Gerber, Börjesson, Ljung, Lindwall, & Jonsdottir, 2016; Walter & Du Randt, 2011), and that (ii) micronutrient status affects energy balance, hereby playing an important role in the development of obesity and obesity-related conditions (García OP, Long KZ, & JL, 2009), one plausible strategy is to focus on the promotion of physical activity and multi-micronutrient supplementation.

School-based physical activity interventions are worthwhile because a considerable number of children's daily physical activity is acquired during school hours (Meyer et al., 2013). Moreover, school-based physical activity programs are generally effective in increasing physical activity and physical fitness in children and adolescents aged 6-18 years (Dobbins, Husson, DeCorby, & LaRocca, 2013). For instance, a randomized controlled trial with Swiss primary schoolchildren (first and fifth graders) showed that physical activity and fitness could be significantly improved via a 1-year school-based physical activity intervention, whereas adiposity could be decreased (Kriemler et al., 2010).

Placing an emphasis on multi-micronutrient supplementation is justified because a meta-analytic evidence suggests that (a) helminth infections and micronutrient deficiencies are highly prevalent in low and middle-income countries (LMICs), (b) a strong relationship exists between helminth infections and serum retinol in school-aged children, and (c) micronutrient-supplementation randomised controlled trials (RCTs) showed a modest, but significant protective effect on helminth infection and reinfection rates (de Gier, Campos Ponce, van de Bor, Doak, & Polman, 2014).



Team kick-off in Basel




▲ Information on the KaziAfya study is provided on the project homepage (www.kaziafya.org).

## *1.2. Purpose of the KaziAfya project*

The goal of the KaziAfya project was to examine the prevalence of infectious diseases and inflammatory and cardiovascular health risk markers in three African countries (Côte d'Ivoire, South Africa and Tanzania) and to test low-cost preventive programs, which combine multi-micronutrient supplementation with physical activity to promote health and well-being among African schoolchildren.

More specifically, three interrelated objectives were addressed:

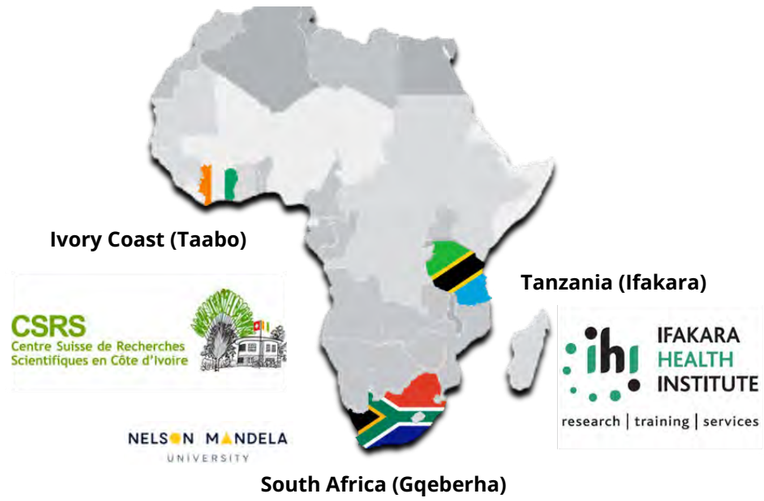
1. To assess infection with helminths and intestinal protozoa, micronutrient deficiencies, and cardiovascular health risk markers (e.g., physical inactivity) in schoolchildren in the involved countries.
2. To determine the association between physical activity, physical fitness, helminth and intestinal protozoa infection, micronutrient status, overweight/obesity, cardiovascular risk markers, cognitive function, and health-related quality of life.
3. To examine the effects of a school-based health intervention (physical activity, multi-micronutrient supplementation, or both) on physical activity, physical fitness, incidence of helminth and intestinal protozoa infection, micronutrient status, overweight/obesity, cardiovascular risk markers, cognitive function, and health-related quality of life.



The study design envisaged that in each of the three countries involved, approximately 330 children participate either in the physical activity or multi-micronutrient supplementation intervention (or in a combination of both), and that 330 children per country constitute a placebo control group. In each country, baseline data of all children is used to assess the relationships between infections, micronutrient deficiencies, and cardiovascular health risk markers.

## *1.3. What does this report offer?*

In this report, we provide general information about the project, give an overview of the variables assessed, present descriptive findings for all variables to document children's health state at baseline, and to visualize changes in health outcomes over time (baseline to follow-up), for the total sample, as well as separately for boys and girls and learners attending different grades. The report is used as a project documentation for the funders, a source containing information for debriefing of different stakeholders, and reference values on schoolchildren's health for future studies in the three participating countries. What this report does not offer are detailed analyses of the various relationships between different variables and detailed analyses on the effects of the intervention. The reasons are that bi- and multivariate relationships and intervention effects need to be examined thoroughly with suitable statistical methods, which is beyond the scope of the present report. Moreover, due to the large number of variables, reporting only certain relationships would seem arbitrary. The examination of the relationships between variables and intervention effects will take more time and insights will be gained gradually. Some of these analyses have already been done and published in peer-reviewed international journals (see chapter 16). Further analyses will follow. An overview and update of publications associated with the KaziAfya study is provided on the project homepage (www.kaziafya.org).



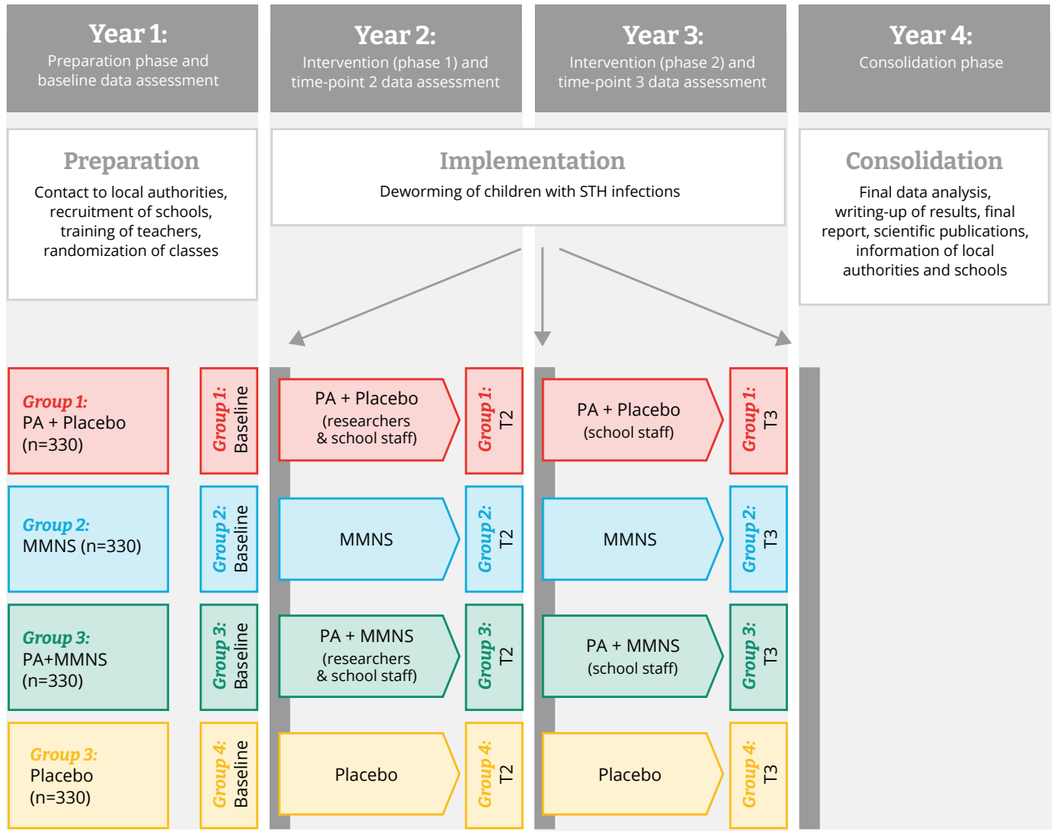

▲ Map of Africa with countries and institutions involved in the KaziAfya project

## *1.4. Study design*

The KaziAfya project was designed as a randomised, double-blind, placebo-controlled trial to assess the effect of physical activity and/or multi-micronutrient supplementation on children's health and well-being. We assessed data at three time points (baseline, post and follow-up). At baseline, children were attending grades 1-4 (approximately 6 to 12 years old). It was planned that the intervention would last approximately 1.5 years and be implemented across two academic years. The project started in January 2018 and lasted until September 2023.

In each country, we recruited a total sample of approximately 1320 children class-wise from public schools, willing to take part in the project, hence providing written informed consent. We randomly assigned classes to one of four groups. The sample size was determined by means of power calculations, with the goal to be able to detect at least small effects in the outcomes.

▼ Graphical representation of the initially planned study design, including timeline




PA = Physical activity,
MMNS = Multi-micronutrient supplementation.



***Table 01.01*** An overview of the measures taken at each of the three assessment time points

| *Measures* | *T1* | *T2* | *T3* |
|---|---|---|---|
| ***Clinical examinations*** | | | |
| ***Disease history of child*** | ■ | | |
| ***Physical examination*** | | | |
| ***Haemoglobin concentration (Hb)*** | ■ | ■ | ■ |
| ***Blood pressure (SBP, DBP)*** | ■ | ■ | ■ |
| ***Blood lipids (TC, HDL-C, LDL-C, TG)*** | ■ | ■ | ■ |
| ***Blood glucose level (HBA1c)*** | ■ | ■ | ■ |
| ***Micronutrient status (vitamin A, zinc, vitamin D, iron)*** | ■ | ■ | ■ |
| ***Anthropometric measurements*** | | | |
| ***Body weight*** | ■ | ■ | ■ |
| ***Body height*** | ■ | ■ | ■ |
| ***Body composition (body fat, muscle mass, bone mass)*** | ■ | ■ | ■ |
| ***Parasitological examinations*** | | | |
| ***Stool samples (A. lumbricoides, hookworm, T. trichiura, S. mansoni)*** | ■ | ■ | ■ |
| ***Physical fitness*** | | | |
| ***20 m shuttle-run test*** | ■ | ■ | ■ |
| ***Grip strength test*** | ■ | ■ | ■ |
| ***Physical activity*** | | | |
| ***Self-reported physical activity (parental survey and child self-report)*** | ■ | ■ | ■ |
| ***Objectively assessed physical activity (7-day accelerometry)*** | ■ | ■ | ■ |
| ***Dietary intake information*** | | | |
| ***Food insecurity assessment (parental survey)*** | ■ | | |
| ***Dietary intake (parental survey)*** | ■ | | |
| ***Cognitive and academic performance*** | | | |
| ***Executive function (Flanker-task)*** | ■ | ■ | ■ |
| ***School grades*** | ■ | ■ | ■ |
| ***Psychosocial health*** | | | |
| ***Socioeconomic and demographic profile (parental survey)*** | ■ | | |
| ***KIDSCREEN-52 (child self-report)*** | ■ | ■ | ■ |
| ***Subjective health complaints (child self-report)*** | ■ | ■ | ■ |
| ***Sleep quality*** | ■ | ■ | ■ |
| ***Sleep environment*** | ■ | | |
| ***School perceptions (child self-report)*** | ■ | ■ | ■ |

▲ Blood pressure

▲ Completing questionnaires

▲ Clinical examinations

▲ Preparing actigraph

▲ Grip strength test

In Tanzania, the KaziAfya project was carried out in public primary schools in the area of Ifakara (for more information about the study setting see chapter 2). We included children if they attended grade 1-4 classes, and if they were aged between 5 and 12 years. The study was restricted to this age group to avoid increased body composition variability due to differences in the onset of puberty in older children. Further inclusion criteria were (i) written informed consent by a parent/guardian; (ii) not participating in other clinical trials; and (iii) not suffering from medical conditions, which prevent participation in physical activity, as determined by qualified medical personnel. We excluded children from data analyses (but not from the intervention) if they (i) had a congenital or acquired alteration of the gastro-intestinal tract, which could impair absorption of the supplements, and (ii) had taken vitamin and mineral supplements in the past 6 months. Children were also excluded from the study and referred to local clinics if they suffered from severe malnourishment (as diagnosed by a study nurse, following national guidelines).

Types of data collected included (i) quantitative data on anthropometric measurements, parasitological status, cardiovascular health risk markers, physical activity, fitness, cognitive performance and psychosocial health, and (ii) qualitative data, based on systematic observations and semi-structured interviews, on the program implementation. The collected quantitative data was double-entered and validated using EpiData (version 3.1) and merged into a single database.

To determine the spectrum and magnitude of infectious diseases or cardiovascular health risk markers among study participants, we applied a suite of standardised, quality-controlled techniques. Table 01.01 provides an overview of the measures that we assessed at baseline (T1), post (T2) and follow-up (T3). Clinical examination of the children included history taking, physical examination, and pertinent investigations to assess for infection and complications of helminth infection. Features of disease history focused on fevers, constitutional symptoms, abdominal pain, change in bowel movements, and diabetes. The physical examination was directed towards evidence of anaemia, abdominal examination, and evidence of pulmonary hypertension.

***Table 01.02*** Distribution of intervention arms across schools and grade levels

| | *School 1* | *School 2* | *School 3* | *School 4* |
|---|---|---|---|---|
| ***Grade 1*** | PA | Control | PA + MMNS | MMNS |
| ***Grade 2*** | MMNS | PA | Control | PA + MMNS |
| ***Grade 3*** | PA + MMNS | MMNS | PA | Control |
| ***Grade 4*** | Control | PA + MMNS | MMNS | PA |

PA = Physical activity.
MMNS = Multi-micronutrient supplementation.

School class



Supplements

Supplement pots

## *1.5. Ethical considerations*

KaziAfya was carried out in accordance with the protocol and with principles in the current version of the Declaration of Helsinki and the guidelines of Good Clinical Practice (GCP) issued by the International Conference of Harmonisation (ICH). Before the start of the data assessment, we received approval from all required authorities. In Switzerland, the study was approved by the Ethikkommission Nordwest- und Zentralschweiz (EKNZ; reference number Req-2018-00608), in Tanzania by the responsible ethics committee of the Ifakara Health Institute (IHI–IRB), the National Institute for Medical Research (NIMR) and the Tanzania Food and Drugs Authority (TFDA). The intervention study has been registered in the ISRCTN registry (http://www.isrctn. com/ISRCTN29534081).

## *1.6. Contents of the intervention*

The majority of the existing school-based interventions that aimed at improving schoolchildren's health have focused on a single type of intervention, such as PA or nutrition, and have primarily targeted children in their first 5 years of life. However, important processes of brain development continue during later childhood, and research is also needed to identify factors that impact on the development of primary schoolchildren living in marginalized areas. From the literature, it is currently unclear whether a combined physical activity and multi-micronutrient supplementation intervention would result in greater improvements in child development than a single intervention.

***Important processes of brain development continue during later childhood, and research is also needed to identify factors that impact on the development of primary school children living in marginalized areas.***

We therefore compared four treatment arms: (a) physical activity + placebo; (b) multi-micronutrient supplementation; (c) physical activity + multi-micronutrient supplementation; and (d) placebo (see Table 01.02). The placebo only concerns the multi-micronutrient supplementation. For physical activity, no real placebo exists. Classes assigned to the placebo or multi-micronutrient supplementation condition followed their normal lesson plans. Therefore, we can ensure that students of these classes (without physical activity component) had the same amount of contact with schoolmates and teachers as students assigned to the physical activity or physical activity + multi-micronutrient supplementation conditions. Assignment of classes to condition was done via stratification to ensure that each intervention arm was represented at each grade across all schools.

### *Physical activity intervention*

Regular physical activity opportunities were incorporated into the main school curriculum including two weekly 45-60 min physical activity lessons consisting of dancing-to-music (one lesson) and playful physical education (one lesson). These intervention materials have been pilot-tested in 2015 and 2016 in the 'Disease Activity and Schoolchildren's Health' (DASH) study with fourth grade children from South Africa attending under-privileged schools in Gqeberha township areas. Qualitative data revealed that the DASH physical activity materials were well received at all schools. Meanwhile, the physical activity intervention materials have been expanded and now cover all primary school grades (KaziKidz toolkit). A detailed description of the KaziKidz toolkit can be found at www.kazibantu.org, including concrete and freely available lesson plans for grade 1 to 7. All schools were equipped with basic sports equipment that allows for the implementation of physical education and moving-to-music lessons.

***Table 01.03.*** Content of the multi-micronutrient supplementation chewing tablets

| *No.* | *Nutrient* | *Average per 1 tablet* |
|---|---|---|
| *1* | β-carotene | 3.6 mg |
| *2* | Vitamin D | 400 IU / 10 mcg |
| *3* | Vitamin E | 9 mg TE |
| *4* | Vitamin K | 30 mcg |
| *5* | Vitamin C | 60 mg |
| *6* | Vitamin B1 Thiamine | 1.1 mg |
| *7* | Vitamin B2 Riboflavin | 1.3 mg |
| *8* | Vitamin B6 Pyriodoxine | 0.5 mg |
| *9* | Vitamin B12 | 1.2 mcg |
| *10* | Folic Acid | 200 mcg |
| *11* | Niacinamide | 8 mg |
| *12* | Iron (added as Fe-EDTA) | 8 mg |
| *13* | Zinc (added as Zinc Oxide) | 5 mg |
| *14* | Selenium (added as Sodium Selenite Anhydrous) | 20 mcg |
| *15* | Iodine (added as Potassium Iodate) | 100 mcg |




▲ Team preparing micronutrients for schools

▲ Teacher workshop

### *Multi-micronutrient supplementation intervention*

Participants allocated to the multi-micronutrient supplementation condition received a daily chewable tablet containing vitamins and trace elements (see Table 01.03). The multi-micronutrient supplement was provided free of charge by DSM Nutritional Products Ltd. (Basel, Switzerland; see: www.dsm.com). The exact composition of the multi-micronutrient supplement is presented below. During school days, the supplement was taken at schools under the direct supervision of a teacher. To avoid the risk that supplements were exchanged between students or given to other family members during week-ends or public holidays, no supplements were provided on non-school days. Children who did not receive multi-micronutrient supplementation (physical activity only and control conditions) received a placebo product. Thus, during school days, they received a daily chewing tablet, similar in taste and appearance to the multi-micronutrient supplementation and administered to the children from identical packages. The tablet did not contain any macronutrients or micronutrients, except sugar, citric acid, water and artificial flavour (orange) to mask the taste and to ensure similar appearance.

### *Deworming*

Independently of the study arm allocation, children diagnosed with helminth infections received deworming medication after each data assessment. The treatment strategy chosen for each school followed national and international guidelines, the latter put forth by the Department of Control of Neglected Tropical Diseases of the World Health Organization (WHO, 2006). That is, if soil-transmitted helminth infection prevalence was below 20%, infected children were treated individually; if soil-transmitted helminth infection prevalence was between 20 and 50%, annual mass treatment was performed once per year; and if soil-transmitted helminth infection prevalence was ≥50%, mass treatment was carried out twice a year.

## 1.7. Training of teachers and school staff

From previous experiences, we were aware that teachers needed considerable support for the physical education lessons. Simple lessons were prepared, and schools were provided with the basic sports equipment needed (e.g., balls, colour bands, beacons, whistle, stopwatches, skipping ropes, hula hoops, etc.). During the first year of intervention, teachers were taught simple class management techniques and assisted by a trained physical education (PE)-coach on a weekly basis. During the second year of intervention, it was envisaged that physical activity intervention should be carried out by the teachers themselves.

## 1.8. Risk evaluation

When planning the study, several potential risks were identified that could pose a challenge to the implementation of the study. Technical risks included getting novel diagnosis into a specific country, large class sizes and the unavailability of electricity and internet, importation of study material and exchange of samples beyond national boundaries, stealing of expensive study material. Operational risk included the presence of multiple local languages, access to parents to obtain written informed consent, priority on traditional medicine and reluctance with regard to multi-micronutrient supplementation, as well as hierarchies within the local society. Another difficulty was related to daily hot temperatures lack of energy intake in some children that may affect the performance of the study participants, especially in the physiological fitness tests. On an individual level, perceived shamefulness of the submission of stool samples by schoolchildren was identified as a further potential issue. Additionally, the application of albendazole and praziquantel (as a deworming treatment) can result in adverse event, but these are usually rare, mild and transient, and typically disappear after a few hours. On a societal level, Tanzania has a solid democratic and constitutional framework. Separation of powers, independence of the judiciary and parliamentary work are constitutionally guaranteed. During the project period, Vice President Samia Suluhu Hassan was appointed Tanzania's new head of state following the sudden death of President Magufuli in March 2021. In order to promote the country's development, the government of Tanzania is focusing on improving state services (infrastructure, health, education, water supply) and on creating jobs through increasing industrialization. Like her predecessor, President Hassan also wants to increase the state's own revenue and fight corruption.

### *Challenges*

A number of challenges arose during the course of our trial in Tanzania due to delays in obtaining research and ethical permits, complications related to COVID-19, resistance to participating in the study interventions, and budgetary constraints.

The delay in commencing and progressing with the study activities was primarily due to unexpected hurdles in obtaining ethical and research clearance. Due to the new Tanzanian regulations, which classify the supplementation of micronutrients in the same way as testing medications, the study was treated as a fully randomized clinical trial. This required additional permits from the Tanzania Medicines and Medical Devices Authority (TMDA) and mandatory clearances from quality assurance authorities, significantly prolonging the process. Therefore, the South African-manufactured multi-micronutrient supplements expired, requiring us to wait for a new batch to be produced. In addition, the clinical trial status entailed unexpected expenses, such as mandatory health insurance for all participants.

As a result of COVID-19 directives, our project schools were closed, which caused further disruptions to our research schedule. Despite the reopening of Tanzanian schools after three months, ongoing advisories against gatherings impeded the progress.

A further challenge was the resistance of parents, teachers, and students to taking multi-micronutrient supplements. There were many who associated the supplements with the controversy surrounding COVID-19 vaccines, leading to hesitancy and withdrawal from the study. Despite our efforts to clarify the distinction between supplements and vaccines, ethical guidelines prevented us from persuading individuals to continue participation.

Additionally, parents expressed resistance to their children wearing the hip-worn accelerometers, which are used for monitoring their physical activity over seven days. Some parents believed that these devices (Actigraph) might harm their children's health, particularly boys, resulting in some withdrawing their children from the study.

Furthermore, some children had difficulty engaging fully in physical activities due to hunger. Many students arrived at school hungry, and most schools did not provide meals.

In classes with up to 100 students, it was difficult for a single teacher to engage all students in adequate physical activity, even with the assistance of a physical education coach. The lack of a school uniform for physical education class was particularly problematic for older girls.

## 1.9. Involved institutions

KaziAfya is a joint project of the Department of Sport, Exercise and Health (DSBG) of the University of Basel (Basel, Switzerland), the Swiss Tropical and Public Health Institute (Swiss TPH, Basel Switzerland), the Ifakara Health Institute (IHI, Ifakara, Tanzania), the Centre Suisse des Recherches Scientiques en Côte d'Ivoire (CSRS, Abjdjan, Côte d'Ivoire), and the Nelson Mandela University (NMU, Gqeberha, South Africa). The trial steering committee was composed of the sponsor-investigator (Prof. Dr. Markus Gerber, University of Basel), the director of the Swiss TPH (Prof. Dr. Jürg Utzinger), and the principal investigators of the three study countries (Dr. Honorati Masanja, IHI, Prof. Dr. Bassirou Bonfoh, CSRS, Prof. Dr. Cheryl Walter, NMU).

The Swiss TPH has a strong track record in transnational global health research consortia and experience in the diagnosis, epidemiology, management and control of infectious diseases and NCDs, including study design, power calculation, implementation and conduct of cohort studies, quality of life assessments and randomised controlled trials.

The Department of Sport, Exercise and Health at the University of Basel has strong competencies in assessing physical fitness, physical activity, psychosocial health, cognitive performance and executive function, and in carrying out school-based health promotion programs.



### *Ifakara Health Institute (Ifakara, Tanzania)*

The Ifakara Health Institute (IHI) stands as a prominent health research and training institution situated in Ifakara, Tanzania, with additional offices in Dar es Salaam, Ikwiriri, and Bagamoyo, Tanzania. Since its inception in 1956, the institute has been dedicated to conducting health-related research across a spectrum of domains, notably malaria and HIV/AIDS. Central to its mission is the pursuit of biomedical and applied health research, with a particular emphasis on infectious diseases, environmental health, and the fortification of health systems. Employing a multidisciplinary approach that integrates epidemiology, entomology, social sciences, and laboratory sciences, IHI addresses health challenges within Tanzania and beyond.

The institute is guided by a core strategic mandate encompassing research, training, and service provision. Ifakara comprises an expansive array of scientific disciplines, ranging from fundamental biomedical and ecological sciences to clinical trials, health systems research, policy translation, and the implementation of health programs. Its work is organized into three research departments, six research units, and seven technical support units. These departments include Environmental Health & Ecological Sciences (EHES), Interventions & Clinical Trials (ICT), and Health Systems, Impact Evaluation & Policy (HSIEP).

Aligned with its vision of fostering "A healthy and empowered population with access to evidence-based health services and solutions" and its mission to serve as a centre of excellence that informs health policies and the delivery of quality services collaboratively through research, innovation, capacity strengthening, and program implementation, IHI has demonstrated its commitment through initiatives like the KaziAfya study. This endeavour brought together researchers and students from various disciplines, including public health, human nutrition, medical laboratory sciences, and nursing.

***Department of Sport, Exercise and Health, University of Basel (Basel, Switzerland)***

The mandate of the Department of Sport, Exercise and Health (DSBG) of the University of Basel is to investigate the relationships between physical activity and health across the lifespan, and to translate research into concrete action for the benefit of the people.

Prof. Dr. Markus Gerber (principal investigator), Dr. Christin Lang (study coordinator), Prof. Dr. Uwe Pühse (co-applicant), Johanna Beckmann (PhD student), Anita Weiss (research assistant).

***Swiss Tropical and Public Health Institute (Basel, Switzerland)***

The mandate of Swiss TPH is to contribute to the improvement of population health nationally and internationally through excellence in research, services and teaching and training.

Prof. Dr. Jürg Utzinger (co-applicant), Dr. Kurt Long (co-applicant), Dr. Peter Steinmann (project consultant).

***Prof. Dr. Markus Gerber***

***Principal Investigator, Main Applicant***

***Dr. Christin Lang***

***Study Coordinator***

***Prof. Dr. Uwe Pühse***

***Co-Applicant***

***Prof. Dr. Jürg Utzinger***

***Co-Applicant***

***Dr. Kurt Long***

***Co-Applicant***

***Dr. Peter Steinmann***

***Project Consultant***

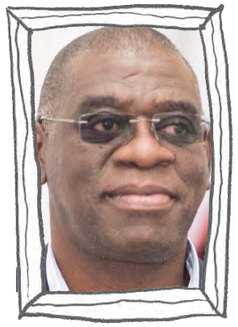
***Ms. Johanna Beckmann***

***PhD Student***

***Anita Weiss***

***Research Assistant***

## *1.10. Tanzanian research team*



### *Dr. Honorati Masanja*

***Function and task:***
Tanzanian PI for the KaziAfya Project

- Part of the initial study design team
- Overall monitoring and coordination of the interdisciplinary components of the Tanzania study
- Research ethics through National Institute of Medical Research (NIMR) and Ifakara Review Board (IRB)
- Contribution to manuscripts and publications

### *Prof. Dr. Fredros Okumu*

***Function and task:***
Project consultant

- Part of the initial study design team
- Overall monitoring and coordination of the interdisciplinary components of the Tanzania study
- Research ethics through National Institute of Medical Research (NIMR) and Ifakara Review Board (IRB)
- Contribution to manuscripts and publications

### *Dr. Lina Finda*

***Function and task:***
Local project-coordinator

- Oversight on implementation of the Tanzania component of the project
- Research coordination and management of data collection and data analysis
- Monitoring of school intervention and organization of teacher workshops and training
- Preparation of study findings and presentation of research findings at conferences
- Contribution to manuscripts and publications

### *Dr. Gertrud J. Mollel*

***Function and task:***
Project partner

- Project medical doctor
- Contributing to research ethics through National Institute of Medical Research (NIMR) and Ifakara Review Board (IRB)
- Contributing to manuscripts and publications

### *Ms. Elihaika Minja*

***Function and task:***
PhD student

- Research coordination and management of data collection and data analysis
- Monitoring of school intervention and organization of teacher workshops and training
- Supported the project coordinator with various administrative tasks
- Team leader of all field activities
- Coordination and management of data collection and data cleaning for anthropometric, questionnaire, blood sample and shuttle run teams
- Management of the volunteers, school teachers and assistant payments
- Various administrative duties such as communicating with schools, compiling the Master datafile and merging data
- Responsible for the printing, filing and storing of data collection sheets and consent forms
- Contribution to manuscripts and publications

### *Dr. Emmanuel Mrimi*

***Function and task:***
Co-researcher

- Team leader of blood sampling, actigraphy and flanker team
- Contribution to the implementation of the Tanzania component of the project
- Contribution to the application for research ethics at National Institute of Medical Research (NIMR) and Ifakara Review Board (IRB)
- Assisting with school intervention, teacher workshops and training
- Contribution to manuscripts and publications

## *Ms. Winfrida Mponzi*

***Function and task:***
Research assistance

- Assistance with implementation of the Tanzania component of the project
- Assistance with school intervention, teacher workshops and training
- Team leader of Tanita team
- Assistance administrative duties such as communicating with schools, management of the volunteers and assistant payment

## *Team of volunteers*

***Actigraphy Team***
- Jacob J Nyoka
- Binzua O Mbaga
- Mwansiti Ngonyani

***Flanker Task Team***
- Festo Tangaliola
- Faisal Mangwale
- Calorine Ndwata

***Clinical Assessment Team***
- Faisal Mwansiti Ngonyani
- Irene Ngoja
- Ayubu Nyatuka
- Ahmad Nyatuka
- Tabia Kikala
- Lucian Sanga
- Susan Alex

***Tanita and Blood Assessment Team***
- Alfred Simfukwe
- Benson B Makua
- Joyce J Jackson
- Magdalena Isaya
- Philemon Ngwilla

***Questionnaire Team***
- Noelia Pama
- Shani Mbaruku
- Mwansiti Ngonyani
- Nuru Nchimbi
- Asma Kasanga
- Godian Selemani
- Bertha Mwandyala
- Tumpe Mwandalya

***Shuttle Run Team***
- Nico Mazehe
- Salehe Makuka
- Sigfred Manyasi
- Issa Kinyakali
- Good Chansi
- Paulo Mnyiwa
- Hendrick Somba
- Philipo Mapango



## *UNESCO Chair*

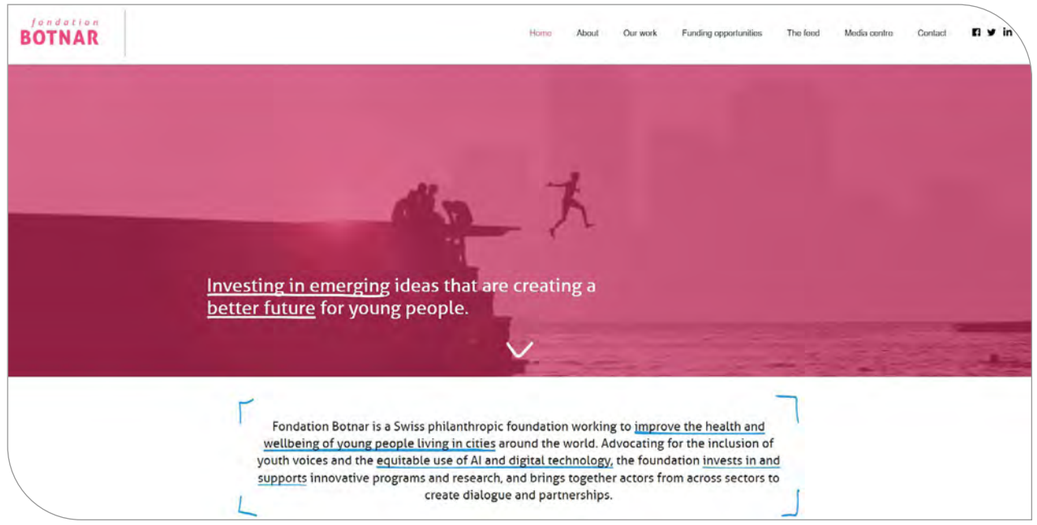
The KaziAfya project is carried out in close cooperation with the UNESCO Chair on Physical Activity and Health in Educational Settings. The Chair focuses on a range of topics surrounding 'Physical Activity and Health in Educational Settings'. The Chair is established by an agreement between UNESCO and the University of Basel. It has been installed in April 2019 and has been renewed in 2023.

It is part of the UNITWIN/UNESCO Chairs Program, which was launched in 1992 by decision of the UNESCO General Conference. Its aim is to promote and strengthen international cooperation, especially North-South, South-South and North-South-South cooperation between universities, colleges and research institutions. In this network, higher education and research institutions pool their human and material resources to address urgent challenges and contribute to the development of society. In many cases, the networks and chairs serve as think tanks and bridge builders between academia, civil society, local communities, research and policy. Today, more than 850 institutions in 117 countries are involved in the UNITWIN/UNESCO Chairs Program.

## *Funding*

### *Fondation Botnar*

The main funding for the KaziAfya project was provided by Fondation Botnar (Basel, Switzerland). The Fondation Botnar is a Swiss philanthropic foundation working to improve the health and well-being of young people living in cities around the world. Advocating for the inclusion of youth voices and the equitable use of artificial intelligence and digital technology, the foundation invests in and supports innovative programs and research, and brings together actors from across sectors to create dialogue and partnerships.




▲ Fondation BOTNAR website (www.fondationbotnar.org)

### *DSM*

The multi-micronutrient supplementation and the placebo products are sponsored by DSM Nutritional Products Ltd. (Basel, Switzerland).

### *Amt für Ausbildungsbeiträge des Kantons BS*

Elihaika Minja has received an "Amt für Ausbildungsbeiträge BS Scholarships (AFA)" to do her PhD study for three years. The scholarship covers the living expenses and education costs of the student.

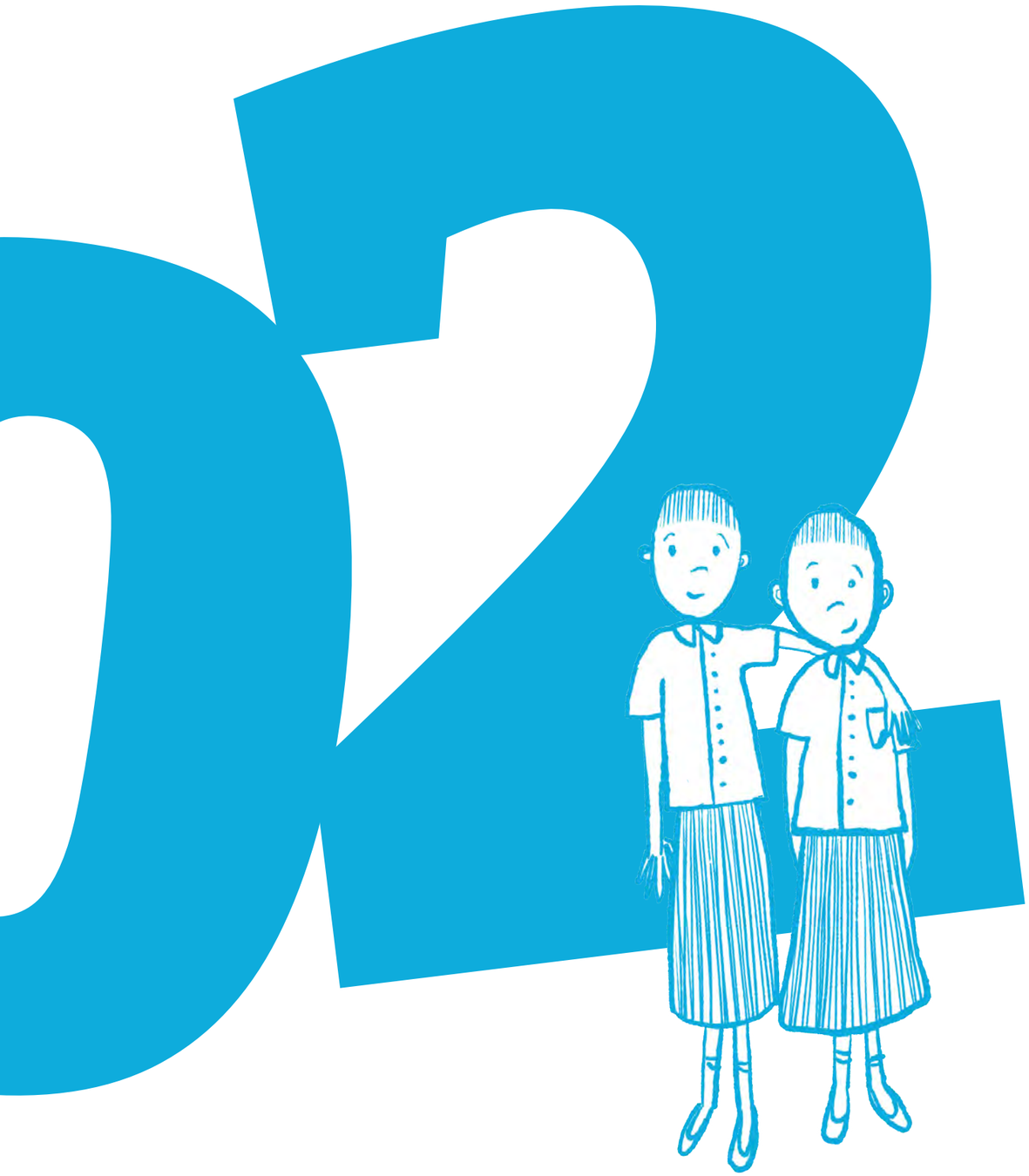
### *Novartis Foundation*

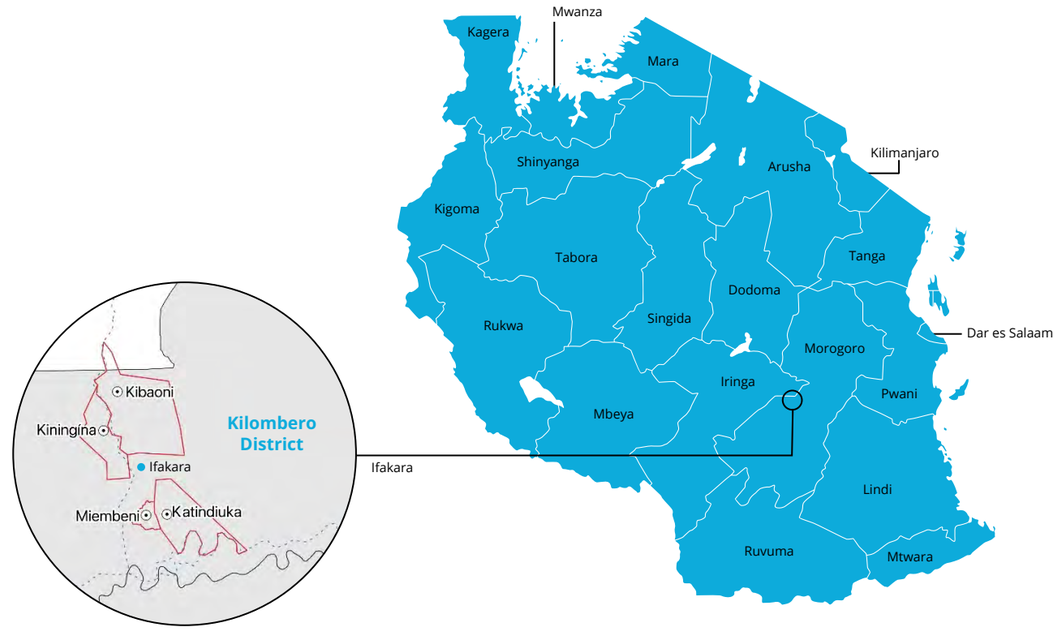
The KaziAfya teaching material is based on (or an extension of) the development of the KaziKidz teaching material, an initiative financially and technically supported by the Novartis Foundation since 2017.

▲ Children with their KaziAfya shirts

▲ Children at school

# *Study sites and schools*






▲ Map of Tanzania and location of study areas

## *2.1. Ifakara*

The KaziAfya project took place in Ifakara Town Council, Kilombero district, Tanzania, situated in the Southeastern part of the country (8.0677°S latitude, 37.1259°E longitude). The Kilombero district shares borders with rural Morogoro to the East and Kilosa district to the Northeast. The Ifakara Town Council comprises one division, further divided into 9 wards, 11 villages, 33 streets, and 64 sub-villages. Of these wards, five are urban and four are rural. Covering an area of 3,893 km², the Ifakara Town Council boasts predominantly flat topography, nestled within a vast floodplain bordered by the Kilombero river to the Southeast and the Udzungwa Mountains to the Northwest. The native inhabitants are mainly of Bantu descent, and include the Ndamba, Mbunga, and Ngindo ethnic groups in addition to smaller tribes like the Pogoro, Hehe, and Bena. Recent years have seen an influx of immigrants, notably the Masai, Sukuma, and Barbaigs, engaged primarily in livestock keeping. The primary economic activities of Ifakara residents encompass agriculture, livestock and fisheries, and some industrial pursuits. Subsistence farming of maize and rice dominates, supplemented by crops like legumes, bananas, cassava, sweet potatoes, cowpeas, and vegetables, albeit on a smaller scale. The average household size is five individuals residing in one or two dwellings within a compound. The primary rainy season spans from November to May, with occasional floods affecting various parts of the district.

Ifakara Town's urban landscape is most pronounced in its Western region, where the majority of residents are small-scale business owners. On the other hand, Katindiuka and Mlabani, located on the eastern part of the town, are the most rural and least densely populated of the five wards and are surrounded by seasonal rice farms. The KaziAfya project was conducted in four primary schools located among four wards out of five wards. The four schools were randomly selected from a pool of 33 schools in Ifakara town, and they came from four different wards including: Katindiuka, Kibaoni, Kining'ina and Mlabani.

### *2.2. Schools and neighbourhoods*

# *Miembeni Primary School*

## *Mlabani, Ifakara Town Council in Morogoro Region*

Established in 1928 in Mlabani within Ifakara Township, Miembeni Primary School hosts 745 students. As a public institution, it offers tuition-free education, primarily funded by governmental allocations.

Mr. Romwald Richard, the current head teacher, has been in charge of the school for five years. He emphasizes the critical role that the KaziAfya initiative plays in the progress of the school, with its major goal being to improve the health and well-being of its students. We are grateful to the initiative for providing necessary equipment for physical activities, like balls and ropes, and for promoting staff professional development by enhancing physical education curricula. The project has also made it easier to purchase office supplies, such chairs and tables, which has improved the working conditions for teachers. The primary occupations of parents of children at Miembeni Primary School are subsistence farming and small-scale business ventures. They convey their sincere gratitude for the project's ability to provide their kids with medical diagnostics and payment for related costs. The students' enthusiasm for attending class has grown during the project's implementation, and they were even more delighted to get the KaziAfya T-shirts.



# *Katindiuka Primary School*

## *Katindiuka Ward, Ifakara Town Council in Morogoro Region*

Katindiuka Primary School, established in 1976 and has 739 students, is a public institution situated in Katindiuka Ward, located in the Eastern segment of the town. Katindiuka serves as a non-fee-paying school within a sub-economic community characterized by rural settings and low population density. Mrs. Respiciosa Gaudence, the head teacher of Katindiuka for three years, made the following remarks in her brief speech:

Scientists have been able to evaluate pupils' health and provide appropriate medical care when needed thanks to the KaziAfya initiative, which has shown to be a providential asset. At the beginning, several parents were against letting their kids work on the project. However, as time went on, parents became more and more interested in getting their kids involved in the study because of the observable advantages that participating students received. Parents are grateful because they cannot afford to pay for their children's medical care. In addition, the project's purchase of a new printer has made administrative work simpler for teachers, making it easier to print important documents like midterm and weekly exams. Teachers at the school also conveyed their deep gratitude for the project, highlighting its engaging exercises and innovative teaching strategies. Teachers and parents alike express a desire for the project to continue, acknowledging its vital benefits in giving their kids access to resources for physical education, nutrition education, and continuous medical support.

# *Kibaoni Primary School*

## *Kibaoni Ward in Morogoro Region*

Established in 1970, Kibaoni Primary School is a public institution situated in Kibaoni Ward with approximately 850 students, located in the Western segment of the town. Kibaoni serves as a non-fee-paying school with the second-highest enrollment of students. The principal of the school, Mr. Kembamba Mbarouk, expressed appreciation for the project's contribution to early problem identification, encompassing not only the health issues of children such as malaria and malnutrition, but also academic and physical fitness concerns, notably through shuttle run assessments. According to his view, "the KaziAfya project has significantly benefited our students, particularly in the realm of health, while also contributing to academic advancement. Through this initiative, we acquired a printer machine, which has proven immensely useful. Additionally, our teachers expressed gratitude for the knowledge gained in physical education lessons during the project, recognizing its role in promoting the health of both students and staff, thereby enhancing student attendance".

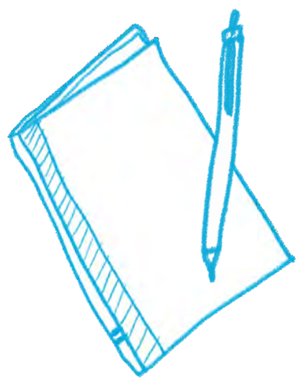


# *Kining'ina Primary School*

## *Kibaoni Ward in Morogoro Region*

Kining'ina Primary School is a public school in Kibaoni ward, which is in the Western part of the town. It was founded in 1975 and has 739 students. Kining'ina is a non-fee-paying institution. The principal, Mr. Renatus Mdumula, has been in this position for ten years.

Regarding the impact of the KaziAfya project, Mr. Renatus Mdumula said during his speech that "parents express profound gratitude as they are unable to cover their children's medical expenses. Additionally, the project's purchase of a new printer has made administrative work for instructors easier and made it easier to print important documents like midterm and weekly exam results. The school's faculty also expressed their heartfelt gratitude for the project, praising its engaging activities and creative teaching strategies. Teachers and parents are in agreement that the project should continue because they understand its critical importance in giving their kids access to resources for continuing medical care, dietary counseling, and physical education".



# *Sample characteristics*

03

***Informed consent was obtained from 1055 parents and guardians. Of these children, 1044 could be assigned to one of the four intervention conditions, and 1037 had valid data with regard to sex (n=543 girls, 52.4%, n=494 boys, 47.6%). Most of these children attended Katinkdiuka school (n=345, 32.7%), followed by Kibaoni (n=257, 24.4%), Miembeni (n=254, 24.1%) and Kining'ina (n=199, 18.9%) (see Table 03.01). The distribution across school grades was very similar, with 226 children (21.6%) attending grade 1, 232 children (22.2%) grade 2, 325 children (31.1%) grade 3, and 261 children (25.0%) grade 4.***

In total, 843 parents/guardians (80.7% of the total baseline sample) completed the parental survey. The parental survey was most frequently completed by the father (n=559, 66.3%), followed by a grandparent (n=97, 11.5%), a relative (n=75, 8.9%), the mother (n=69, 8.2%) or a sibling (n=37, 4.4%).

Most of the parents/guardians indicated that their children speak Swahili language at home (n=838, 99.4%). Other languages (Sukuma, Haya) were rarely reported. Income followed a normal distribution with most of the families earning between 100'000 to 199'000 Tanzania Schilling (TZS) per month.

**1055**

***children participated in the data assessment at baseline.***

**494**

***children were boys.***

**543**

***children were girls.***

Information about the living conditions of the participating children is shown in Table 03.01. Most families had access to farmland or a field (n=599, 71.1%) and kept animals such as chicken (n=382, 45.3%), cow (n=15, 1.8%), pig (n=44, 5.2) or goat/sheep (n=7, 0.8%). With regard to other household assets, approximately every third family had access to a radio (n=322, 38.2%) or to a mobile phone (n=279, 33.1%). In addition, every fourth family had access to a washing machine (n=212, 25.1%) or to a TV (n=212, 25.1%). Compared to that, relatively few families possessed a fridge (n=62, 7.4%), a fan (n=8.2%) or a computer (n=7, 0.8%). Only one family had a car (0.1%), whereas 539 families (63.9%) owned a bicycle.

Regarding the housing conditions, most of the children lived in a house built of bricks (n=775, 91.9%) or mood (n=64, 7.6%). Typically, houses had a metal (n=752, 89.2%) or thatched roof (n=90, 10.7%). Most of the houses had between two (n=332, 39.4%) or three (n=238, 28.2%) bedrooms. Furthermore, most of the houses were equipped with a flush toilet located outside the house (n=592, 70.2%). Pit latrines were also common (n=162, 19.2%), whereas only 10.6% (n=89) of the children had access to a toilet inside the house. The most common source of light in the houses was solar energy (n=300, 35.6%), followed by battery (n=268, 31.8%) and electricity (n=234, 27.8%). The most frequently reported source of cooking was wood (n=534, 63.3%).

***Table 03.01*** Sample description

| | Total sample | |
|---|---|---|
| *Sex* | *n* | *%* |
| ***Boys*** | 494 | 47.6 |
| ***Girls*** | 543 | 52.4 |
| *Grade level* | *n* | *%* |
| ***Grade 1*** | 226 | 21.6 |
| ***Grade 2*** | 232 | 22.2 |
| ***Grade 3*** | 325 | 31.1 |
| ***Grade 4*** | 261 | 25.0 |
| *School* | *n* | *%* |
| ***Miembeni*** | 254 | 24.1 |
| ***Kining'ina*** | 199 | 18.9 |
| ***Kibaoni*** | 257 | 24.4 |
| ***Katindiuka*** | 345 | 32.7 |
| *Intervention arm* | *n* | *%* |
| ***Placebo*** | 269 | 25.8 |
| ***MMNS*** | 265 | 25.4 |
| ***PA + Placebo*** | 247 | 23.7 |
| ***PA + MMNS*** | 263 | 25.2 |

| *Language spoken** | *n* | *%* |
|---|---|---|
| ***Swahili*** | 838 | 99.4 |
| ***Sukuma*** | 3 | 0.3 |
| ***Haya*** | 2 | 0.3 |
| *Caregiver* | *n* | *%* |
| ***Father*** | 559 | 66.3 |
| ***Mother*** | 69 | 8.2 |
| ***Sibling*** | 37 | 4.4 |
| ***Neighbour*** | 0 | 0.0 |
| ***Grandparent*** | 97 | 11.5 |
| ***Relative*** | 75 | 8.9 |
| ***Guardian*** | 6 | 0.7 |
| *Income* | *n* | *%* |
| ***0–19000*** | 100 | 11.6 |
| ***20000–49000*** | 118 | 14.0 |
| ***50000–99000*** | 167 | 19.8 |
| ***100000–199000*** | 289 | 34.4 |
| ***200000–499000*** | 153 | 18.1 |
| ***≥500000*** | 16 | 1.8 |

| *Access to water** | *n* | *%* |
|---|---|---|
| ***Dug up wells*** | 39 | 4.6 |
| ***Tap water*** | 217 | 25.7 |
| ***Water pump*** | 616 | 73.1 |
| *Living and housing conditions** | *n* | *%* |
| ***Washing machine*** | 212 | 25.1 |
| ***Fridge*** | 62 | 7.4 |
| ***Radio*** | 322 | 38.2 |
| ***Cell phone*** | 279 | 33.1 |
| ***Computer*** | 7 | 0.8 |
| ***Bicycle*** | 539 | 63.9 |
| ***Car*** | 1 | 0.1 |
| ***TV*** | 212 | 25.1 |
| ***Fan*** | 69 | 8.2 |
| ***Farmland / Field*** | 599 | 71.1 |
| ***Chicken / Ducks*** | 382 | 45.3 |
| ***Cow*** | 15 | 1.8 |
| ***Pig*** | 44 | 5.2 |
| ***Goat / Sheep*** | 7 | 0.8 |
| *Type of toilet* | *n* | *%* |
| ***Flush toilet (inside)*** | 36 | 2.9 |
| ***Flush toilet (outside)*** | 23 | 1.3 |
| ***Pit latrine*** | 828 | 92.3 |
| *Roof of house* | *n* | *%* |
| ***Metal*** | 752 | 89.2 |
| ***Thatched*** | 90 | 10.7 |
| ***Other*** | 1 | 19.2 |
| *Wall of house** | *n* | *%* |
| ***Bricks*** | 775 | 91.9 |
| ***Mood*** | 64 | 7.6 |
| ***Wood*** | 4 | 0.5 |
| *Number of bedrooms* | *n* | *%* |
| ***1*** | 145 | 17.2 |
| ***2*** | 332 | 39.4 |
| ***3*** | 238 | 28.2 |
| ***≥4*** | 128 | 15.1 |

| *Source of light** | *n* | *%* |
|---|---|---|
| ***Electricity*** | 234 | 27.8 |
| ***Solar*** | 300 | 35.6 |
| ***Kerosene*** | 40 | 4.7 |
| ***Candles*** | 14 | 1.7 |
| ***Battery*** | 268 | 31.8 |
| ***No light*** | 1 | 0.1 |

*Multiple answers possible.

▲ Child participating in the survey

# Essentials



***Ensuring healthy lives and promoting well-being among children is a complex and challenging endeavour. In many African countries, children are at an increased risk of compromised health due to a dual burden of diseases, which may hamper their development and well-being. Although children are mainly affected by infectious diseases, they may at a young age already develop risk-factors predisposing them to non-communicable diseases in early adulthood. Therefore, the main purpose of the KaziAfya project was to examine the prevalence of infectious diseases and cardiovascular health risk markers in three Sub-Saharan African countries and to test low-cost preventive programs, which combine multi-micronutrient supplementation with physical activity to promote health and well-being among primary schoolchildren.***

The KaziAfya project was designed as a randomised, double-blind, placebo-controlled trial to assess the effect of physical activity and/or multi-micronutrient supplementation on children's health and well-being. In Tanzania, 1055 children attending grades 1-4 were recruited and assessed three times. Several indicators of growth, mental and physical health were assessed. The project started in January 2018 and lasted until September 2023. Data analysis and publication of results are ongoing.

Overall, the children were quite satisfied with their health. Almost 90% of the children rated their overall health as good or very good, whereas only 3% of the children rated their health as poor. The children's subjective representation of well-being was quite stable over time. While a slight improvement occurred from T1 to T2, a decrease in subjective well-being was observed from T2 to T3 (likely due to the outbreak of the COVID-19 pandemic). At T3, boys reported higher overall well-being than girls. Despite this overall positive rating, almost 50% of the children reported that they do not often feel physically fit. Moreover, many children complained that they do not have enough time for themselves, and that they do not get on well at school. Relatively few children reported daily subjective health complaints. The most frequently reported complaints were headaches and stomach aches, which might be responsible for the fact that relatively many children perceived low levels of physical fitness and low levels of energy. Contrary to the international literature, boys felt more often depressed, nervous and irritable than girls.

Approximately 920 children had valid data for self-reported sleep complaints. The most frequently reported sleep complaints were not feeling restored in the morning (23%) and not being able to fall asleep at night (17%). Difficulties falling asleep were more prevalent among younger children. Based on

# 923

***children participated in the clinical examination, in total.***

approximately 850 parental reports, most children went to bed between 7-9 pm in the evening and slept until 6-8 am in the morning. This suggests that most children get the recommended 9-11 hours of sleep per night.

In total, 923 children participated in the clinical examination. The most prevalent disease symptom was cough (26%). All other symptoms were reported by less than 10% of the children (e.g., diarrhea, breathing difficulties, allergies and skin lesions). Jaundice, splenomegaly, hepatomegaly, pulmonary and cardiac auscultations and skin lesions were not found in the present sample (or were very rare). Surprisingly, more than 43% of the children reported that they were taking a medication during the past week (mostly against fewer, flu or pain or against malaria). The percentage of children who took antibiotics was 3%. Most of the children were classified as non-anaemic (88%), whereas 7% presented with mild and 5% with moderate anaemia. With regard to the children's weight status, 5% were classified as underweight, 83% as normal weight, 11% as overweight and 2% as obese. Based on these findings, we can conclude that overnutrition is a more prevalent health issue in this sample than undernutrition. Whereas the percentage of children who were classified as wasted (low weight-for-height) was low (4%), a more substantial portion (14%) was classified as stunted (low height-for-age). Expectedly, girls had higher relative and absolute body fat than boys, whereas boys had higher relative muscle mass and basal metabolic rate than girls. Over time, relative body fat increased significantly among girls, whereas values remained stable in boys.

With regard to cardiovascular risk factors, 18-22% of the children were classified as hypertensive. Diabetes was diagnosed in none of the children, and only few of them were identified as prediabetic. Total cholesterol and LDL cholesterol levels decreased over the course of the study, while HDL cholesterol and triglyceride levels increased. Only few differences were found between boys and girls with regard to changes in risk markers over time.

Children's overall school performances were satisfactory. Only a small percentage of children was unable to keep up in the first four grades. Girls had an advantage over boys in several school subjects, particularly languages and civic/social studies. Despite this, boys did not perceive more pressure at school than girls. In terms of school enjoyment, most of the children liked going to school. Perceived academic competence was on a medium level.

Based on actigraphy data, boys accumulated 148 min of MVPA per day, whereas girls engaged for 118 min per day in MVPA. In line with the overall high physical activity levels, 96% of boys and 91% of girls met international physical activity recommendations (≥60 min MVPA/day). According to the parents' reports, 79% of the children engaged in at least 60 min of physical activity per day on every day of the week, and almost two thirds of the children engaged in sports, dance and other playful games at least two times per week. Time spent for MVPA decreased from T1 to T3, whereas sedentary time increased. A gradual increase in sedentary time was also observed from grade 1 (552 min/day) to grade 4 (611 min/day). About 45% of the children reported that they were often active during school physical education, whereas 44% reported that they were hardly ever active. Overall, children seem motivated to engage in physical activity during school time as more than half of the learners ran or played during recess and more than 33% during lunch time. Regarding their cardiorespiratory fitness

***Overall, children seemed motivated to engage in physical activity during school time.***



levels, the performances observed of the present sample were comparable to those of previous child studies in Tanzania, with Tanzanian children being among the most fit in Sub-Saharan Africa (Lang et al., 2018).

With regard to food security, only few children (4%) reported that they went to bed hungry on the day before the data assessment. Similarly, few children (13%) reported that they did not get anything to eat in the morning before school. Only 5% of the children got one meal (or less) before the day of the data assessment. Approximately 20% of the parents/guardians felt that their household members would not have access to enough food on every day. On average, children consumed around 7 food items from 5 different food groups per day. The most frequently consumed food groups were cereals, sweet beverages, oil, fish, and vegetables.

Regarding the effects of the intervention, the data are currently analysed and results will be published in international peer-reviewed journals. Information regarding implementation quality/fidelity, acceptability of the intervention for students, teachers and parents, and observed challenges are described in a specific chapter as part of this Stakeholder report.

▲ Clinical examination

# *Mental and physical well-being*

## *Background*

Subjective representations of mental and physical well-being are important aspects of children's health-related quality of life (Ravens-Sieberer et al., 2006). Subjective representations of well-being can be used as a benchmark for monitoring population health, to identify subgroups that require specific attention, and to measure the impact of public health interventions within specific populations (Ravens-Sieberer et al., 2001). As a consequence, subjective representations of mental well-being have become an important factor in the medical and caring sciences (Haraldstad et al., 2011). In children, perceived mental and physical well-being proved to be important predictors of health and for estimating health care costs in later life (Seid et al., 2004). Early interventions to improve mental and physical well-being seem important as these constructs are characterised by a remarkable stability over time (Meade & Downswell, 2016). As shown in previous research, many factors can negatively influence subjective well-being, including lower socioeconomic status (von Rueden et al., 2006) or being overweight or obese (Chen et al., 2014). Additionally, mental and physical well-being seem to decline from childhood to adolescence (Bisegger et al., 2005; Michel et al., 2009), and with increasing age, girls tend to report lower well-being than boys (Bisegger et al., 2005; Helseth et al., 2015; Michel et al., 2009).

## *How did we measure mental and physical well-being?*

To assess children's subjective representations of their mental and physical health, we applied the 10-item KIDSCREEN. This instrument assesses children's moods and emotions, self-perception, autonomy, parent relation and home life, financial resources, peers and social support, school environment, and bullying experiences. The KIDSCREEN proved to be a valid instrument to assess psychosocial health of children aged 8-18 years across various countries (Ravens-Sieberer et al., 2008). The construct validity of the KIDSCREEN has been evaluated in an African context (Taliep & Florence, 2012). We previously used the KIDSCREEN in the DASH study, where we found satisfactory psychometric properties of this instrument (Salvini et al., in revision). The KIDSCREEN also allows to calculate an overall index. Following recommended procedures, item scores were first summed up to obtain raw scores and then transformed into Rasch person parameter estimates. These steps resulted in T-values with a scale mean of 50 and a standard deviation (SD) of 10. Higher mean scores generally reflect higher health-related quality of life.

Children at school during break time

Participating children completing questionnaires

## *Results*

In total, the KIDSCREEN was completed by 916 children. As shown in Figure 05.01, children were quite satisfied with their overall health. Taken together, 88.4% of the children rated their general health as good or very good. Approximately nine percent of the children felt that their overall health was only “quite good”, whereas 2.7% of the children rated their health as “poor”.

As shown in Figure 05.02, the scores were relatively high across all domains of well-being. The children reported that they seldom felt sad or lonely. Moreover, most of the children reported that they often had fun with friends, were treated fairly by their parents and were able to pay attention at school. A somewhat less positive picture emerged with regard to the question whether the children felt that they would get on well at school. Here, 26.5% of the children identified a problem. Moreover, more than sixty percent of the children complained that they did not have enough time for themselves and



around 15% were rarely able to do things they want to do. Surprisingly, given the positive overall health perception, more than half of the children indicated that they rarely felt fit and well during the past week, and almost 20 percent perceived relatively low energy levels.

Table 05.01 shows the mean scores separately for boys and girls. Statistically significant differences were found for none of the included variables. Learners in grade 1 to 3 more often felt sad and lonely than peers in grade 4. Whereas learners from grade 4 had the lowest scores with regard to having enough time for themselves, grade 1 learners scored particularly low when it comes to doing things they want to do. The fact that grade 3 learners achieved the highest scores for having enough time for themselves might explain why they more often reported having fun with their friends. The feeling of being treated fairly by their parents dropped from grade 1 to the grade 2, whereas the ability of paying attention at school followed an U-shaped curve, with learners from grade 2 reporting particularly low values.

***Figure 05.01*** Perceptions of general health among the total sample

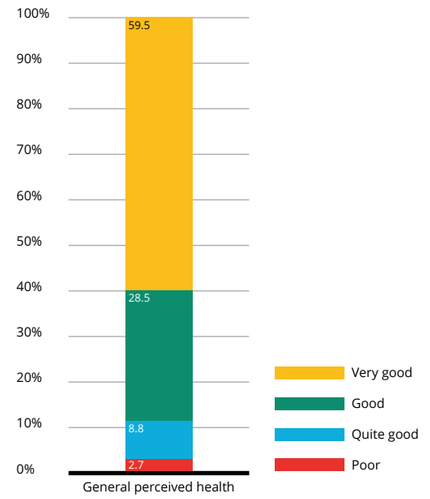



***Table 05.01*** Mental and physical well-being, separately for boys and gilrs and learners attending different grades

| | *Total sample* | | *Boys* | | *Girls* | | *Grade 1* | | *Grade 2* | | *Grade 3* | | *Grade 4* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| ***General perceived health (1–4)*** | 3.46 | 0.77 | 3.46 | 0.78 | 3.45 | 0.76 | 3.39 | 0.79 | 3.48 | 0.70 | 3.43 | 0.79 | 3.52 | 0.77 |
| ***Felt fit and well (1–5)*** | 3.49 | 1.03 | 3.54 | 1.03 | 3.45 | 1.03 | 3.42 | 1.03 | 3.47 | 1.06 | 3.55 | 1.02 | 3.52 | 1.00 |
| ***Felt full of energy (1–5)*** | 3.56 | 1.06 | 3.62 | 1.03 | 3.51 | 1.08 | 3.50 | 1.07 | 3.54 | 1.05 | 3.55 | 1.06 | 3.66 | 1.04 |
| ***Felt sad (1–5)*** | 4.44 | 0.90 | 4.43 | 0.92 | 4.44 | 0.89 | 4.36 | 0.91 | 4.39 | 0.91 | 4.40 | 0.94 | 4.59 | 0.84 |
| ***Felt lonely (1–5)*** | 4.68 | 0.65 | 4.65 | 0.68 | 4.70 | 0.62 | 4.63 | 0.63 | 4.67 | 0.67 | 4.63 | 0.73 | 4.78 | 0.52 |
| ***Enough time for yourself (1–5)*** | 2.03 | 1.14 | 2.07 | 1.14 | 1.99 | 1.14 | 1.99 | 1.02 | 1.99 | 1.11 | 2.19 | 1.20 | 1.88 | 1.16 |
| ***Been able to do things that you want to do (1–5)*** | 3.52 | 1.03 | 3.50 | 1.03 | 3.54 | 1.03 | 3.26 | 0.91 | 3.53 | 1.00 | 3.59 | 1.02 | 3.65 | 1.11 |
| ***Been treated fairly by parents (1–5)*** | 3.85 | 0.82 | 3.83 | 0.80 | 3.86 | 0.84 | 4.04 | 0.75 | 3.81 | 0.76 | 3.71 | 0.82 | 3.86 | 0.90 |
| ***Fun with friends (1–5)*** | 4.02 | 1.15 | 4.05 | 1.12 | 4.00 | 1.18 | 3.95 | 1.06 | 3.96 | 1.12 | 4.18 | 1.14 | 3.94 | 1.25 |
| ***Got on well at school (1–5)*** | 2.91 | 0.69 | 2.95 | 0.69 | 2.91 | 0.69 | 2.85 | 0.64 | 2.88 | 0.62 | 2.92 | 0.73 | 2.98 | 0.74 |
| ***Been able to pay attention to teachers (1–5)*** | 3.88 | 0.75 | 3.89 | 0.73 | 3.87 | 0.76 | 3.89 | 0.75 | 3.73 | 0.72 | 3.91 | 0.73 | 3.96 | 0.77 |

▲ KaziAfya kids

***Figure 05.02*** Mental and physical well-being of the total sample

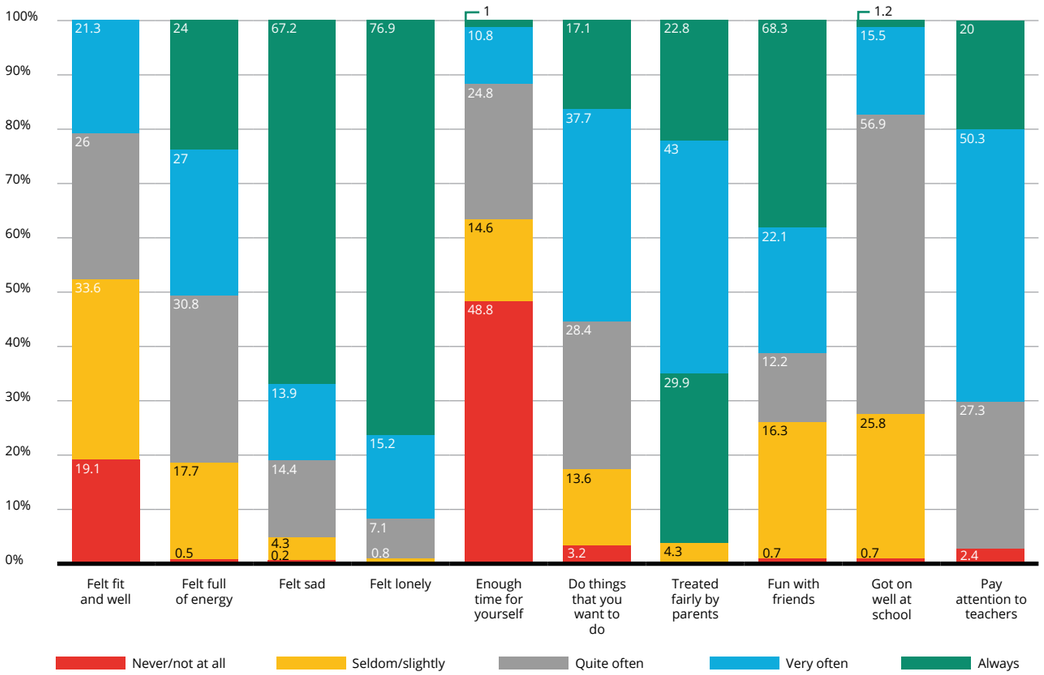
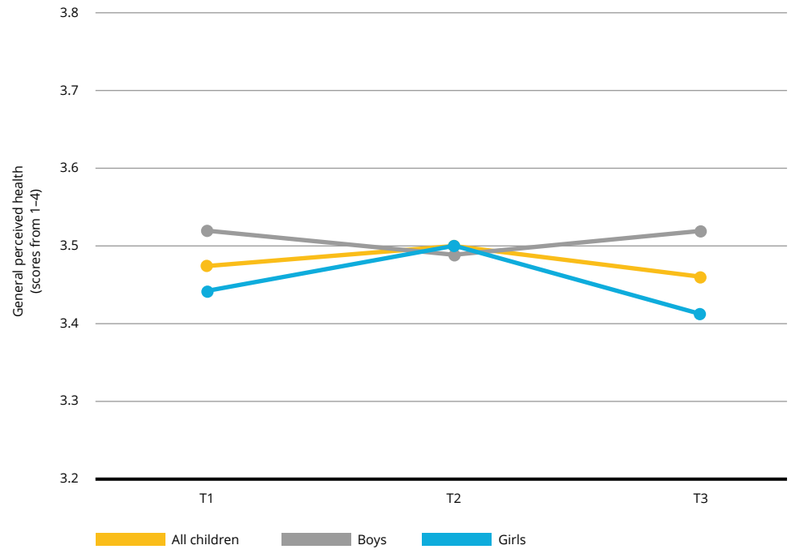




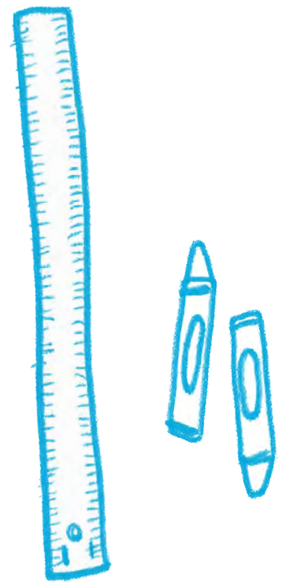

***Figure 05.03*** Development of general perceived health across the study period, for the total sample and separately for boys and girls




Overall, 800 children completed the instrument three times and reported a valid score for their overall health perception. As shown in Figure 05.03, the general health perception remained relatively stable from T1 to T3. This pattern did not differ between boys and girls.

## Conclusion

Overall, a relatively positive picture emerged with regard to the mental and physical well-being of the participating children. Only 2.7% of the learners rated their general health as negative. This is also reflected in most of the subareas of mental well-being. Nevertheless, it should be noted that around 20% of the students reported low energy levels, around 25% had the impression to not get on well at school and more than 60% felt that they did not have enough time for themselves. Moreover, children's subjective representation of well-being was stable across time and, even after the outbreak of the COVID-19 pandemic, no substantial decrease in children's general health perception was observed. A similar development was found for boys and girls.



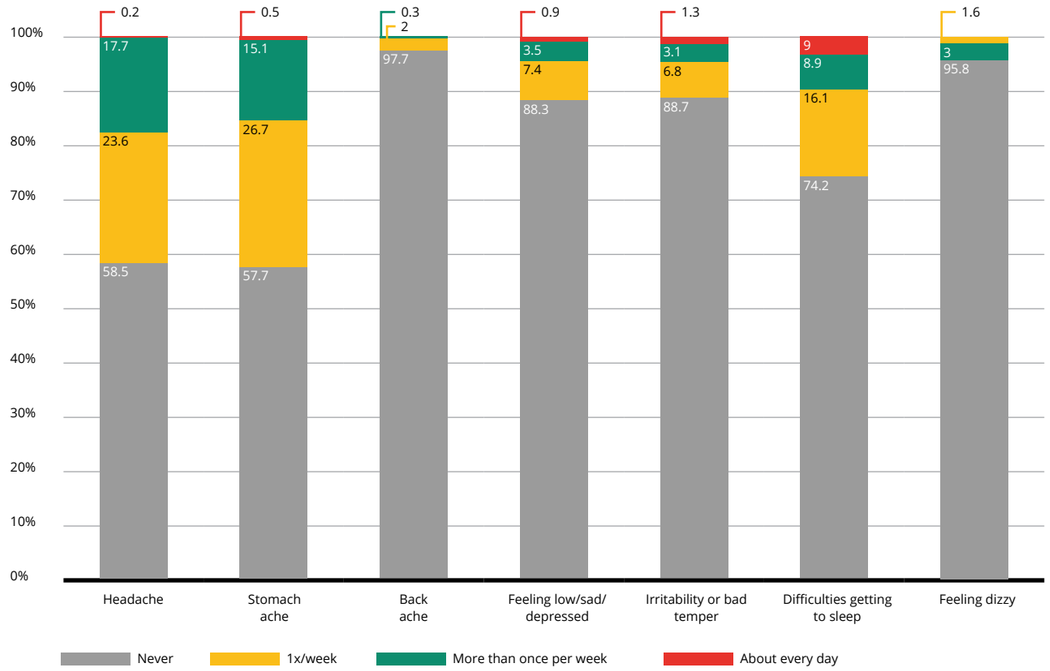
# *Subjective health complaints*

## *Background*

Subjective health complaints (or psychosomatic complaints) refer to physical symptoms or illnesses that are caused or influenced by psychological or emotional factors (Simonsson et al., 2008; Sumter & Baumgartner, 2017). These symptoms occur when the body reacts to stress, fear, grief or other psychological stress (Cozzi et al., 2021). The importance of these complaints in children is that they can indicate unresolved emotional conflicts or mental stress (Berntsson & Gustafsson, 2000; Tanaka et al., 2000). Children may have trouble expressing or understanding their feelings and may develop physical symptoms instead. These complaints can also be an expression of a disturbed balance between body and mind. It is important to take psychosomatic complaints in children seriously and treat them appropriately (Ibeziako & Bujoreanu, 2011). A holistic approach that takes into account both the physical and psychological aspects can help to identify and resolve the underlying emotional conflicts (Forde et al., 2022). Early intervention can help children develop healthy coping mechanisms and avoid long-term effects on their physical and mental health.

***Early intervention can help children develop healthy coping mechanisms and avoid long-term effects on their physical and mental health.***

***Figure 06.01*** Prevalence of subjective health complaints in the total sample

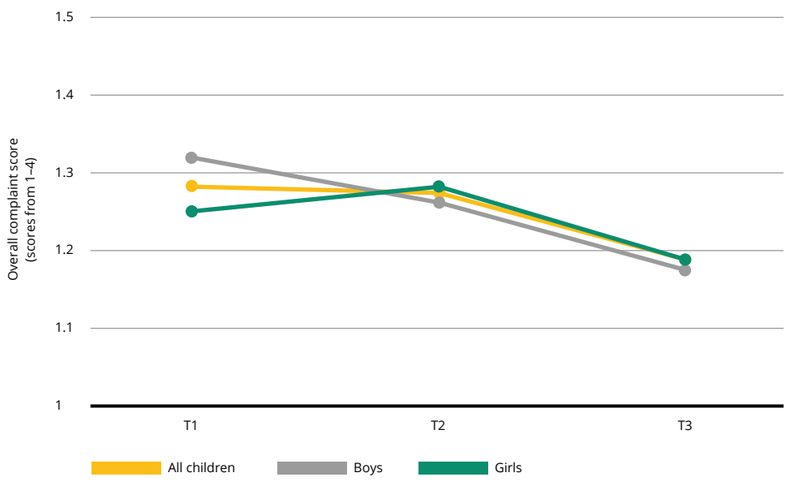



▲ Distributing supplements

***Table 06.01*** Subjective health complaints, separately for boys and girls and learners attending different grades

| | *Total sample* | | *Boys* | | *Girls* | | *Grade 1* | | *Grade 2* | | *Grade 3* | | *Grade 4* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***M*** | ***SD*** | ***M*** | ***SD*** | ***M*** | ***SD*** | ***M*** | ***SD*** | ***M*** | ***SD*** | ***M*** | ***SD*** | ***M*** | ***SD*** |
| ***Headache*** | 1.59 | 0.78 | 1.59 | 0.77 | 1.60 | 0.79 | 1.66 | 0.78 | 1.73 | 0.82 | 1.56 | 0.77 | 1.46 | 0.74 |
| ***Stomach ache*** | 1.58 | 0.76 | 1.59 | 0.76 | 1.58 | 0.76 | 1.64 | 0.74 | 1.73 | 0.79 | 1.54 | 0.74 | 1.46 | 0.74 |
| ***Back ache*** | 1.03 | 0.18 | 1.03 | 0.21 | 1.02 | 0.15 | 1.02 | 0.17 | 1.03 | 0.20 | 1.03 | 0.16 | 1.03 | 0.19 |
| ***Feeling low/sad/depressed*** | 1.17 | 0.51 | 1.21 | 0.55 | 1.14 | 0.47 | 1.10 | 0.37 | 1.19 | 0.54 | 1.25 | 0.63 | 1.11 | 0.41 |
| ***Feeling nervous*** | 1.17 | 0.53 | 1.22 | 0.58 | 1.13 | 0.48 | 1.07 | 0.34 | 1.12 | 0.42 | 1.26 | 0.68 | 1.19 | 0.54 |
| ***Irritability or bad temper*** | 1.39 | 0.75 | 1.49 | 0.81 | 1.29 | 0.66 | 1.24 | 0.58 | 1.26 | 0.57 | 1.5 | 0.85 | 1.48 | 0.84 |
| ***Feeling dizzy*** | 1.05 | 0.28 | 1.07 | 0.30 | 1.04 | 0.24 | 1.05 | 0.29 | 1.09 | 0.36 | 1.05 | 0.26 | 1.03 | 0.17 |
| ***Overall complaint score*** | 1.28 | 0.31 | 1.31 | 0.33 | 1.26 | 0.28 | 1.26 | 0.26 | 1.31 | 0.30 | 1.31 | 0.34 | 1.25 | 0.30 |

***Figure 06.02*** Development of average subjective health complaints across the study period, for the total sample and separately for boys and girls



Blood testing

## *How did we assess subjective health complaints?*

As part of the clinical examination, a research assistant interviewed each child to obtain information about their disease history and psychosomatic complaints. In the present study, we used seven items of the HBSC Symptom to measure subjective health complaints (Haugland & Wold, 2001), including headache, abdominal pain, backache, feeling low, irritability/bad temper, sleeping difficulties, and dizziness. Evidence for the reliability and validity of this measure has been provided previously (Haugland & Wold, 2001). An overall complaint score was built by calculating the mean score across all assessed complaints.



## *Results*

Valid data were available for 923 children. As shown in Figure 06.01, the most frequently reported health complaints (>once per week) were headache (17.9%), followed by stomach ache (15.6%) and irritability/bad temper (9.6%). Feeling nervous (4.3%), feeling low/sad/depressed (4.2%), backache (3.7%), and feeling dizzy (1.2%) were less frequently reported.

Boys reported more often that they feel low/sad/depressed, nervous and irritable than girls, whereas no differences were found in any of the other variables (see Table 06.01). Boys also had a statistically significantly higher overall complaint score than girls. Headache and stomach ache were more frequently reported by grade 1 and grade 2 learners compared to their older counterparts, whereas feelings of nervousness and irritability/bad temper was more frequently observed in grade 3 and grade 4 learners. Grade 3 learners had the highest scores for feeling low/sad/depressed. The latter finding might be attributable to the fact that grade 3 learners perceived more often that they were treated unfairly by their parents (see previous chapter).

In total, 758 children had valid scores across all measurement timepoints. As shown in Figure 06.02, the overall complaint score remained stable from T1 to T2, and then statistically significantly decreased from T2 to T3. The decrease over time (from T1 to T3) was stronger among boys, which was mainly due to the fact that initial baseline differences disappeared until the last measurement time point.

Children preparing for their blood tests

**758**

***children had valid scores across all measurement timepoints.***

## *Conclusion*

In summary, relatively few children reported daily subjective health complaints. This fits with the relatively positive health assessment of the children (see chapter 5). These findings suggest that headaches and stomach aches might be responsible for the fact that relatively many children perceived low levels of physical fitness and low levels of energy.

# *Disease symptoms*

## *Background*

Disease symptoms and infectious diseases can impact on children on both a physical and psychological level. Children with physical health problems may experience limitations in their daily lives, such as limited physical activity, difficulties in school, or social interactions, which in turn can lead to reduced quality of life (Belfer, 2008). Chronic or recurring disease symptoms can also lead to psychological distress such as anxiety, depression or low self-esteem (Pinquart, 2020). Studies have further shown that certain childhood health conditions can be associated with long-term effects in adulthood (Hoftun et al., 2013). In Sub-Saharan Africa, helminth infections are still widespread among children (Müller et al., 2011). Helminth infections are caused by parasitic worms that infect the intestines or other organs in humans (Hotez et al., 2008). In children, several health risks associated with helminth infections have been identified: For instance, helminths can absorb nutrients from the child's diet and thereby lead to malnutrition, which in turn can impair the physical development (Papier et al., 2014). Studies have also shown that children with helminth infections are, on average, shorter and have a lower body weight than children without infections (Raj et al., 2022). Helminths can affect the child's immune system and weaken the immune response to other infections (Helmby, 2009). This can lead to an increased risk of other infections, such as diarrhea and respiratory infections (Melese et al., 2023). There is also evidence that helminth infections can impair cognitive development (Gall et al., 2017; Pabalan et al., 2018). Another widespread health issue in African children is anaemia (Adeyemi et al., 2019; Simo et al., 2020). Anaemia is a condition in which the body does not produce enough healthy red blood cells or they do not function properly (Allali et al., 2017). This can cause various health problems in children such as impaired physical development (Aynalem et al., 2022), impaired cognitive function (e.g., attention, memory and academic performance) (Grantham-McGregor et al., 2007; Mohammed Teni, 2017), decreased physical performance (e.g., reduced cardiorespiratory fitness) (Mani et al., 2005; Tsai et al., 2019), and increased risk of infections (e.g., respiratory infections and diarrhea) (Chandyo et al., 2015; Mourad et al., 2010).

## *How did we assess disease symptoms, use of medication and helminth infections?*

As part of the clinical examination, a research assistant assessed children's disease history in a face-to-face interview. Features of disease history focused on fevers, abdominal pain, change in bowel movements, and diabetes. Additionally, a qualified nurse conducted an abdominal examination. To assess children's anaemic status, we used fingerprick methodology to collect one drop of capillary blood, which was then analysed via a HemoCue® Hb 301 system according to the manufacturer's instructions. Based on the haemoglobin (Hb) concentration, children were classified in four different groups

(non-anaemic, mild, moderate, severe anaemia) based on established cut-offs. For parasitological examinations, a researcher visited the schools and distributed pre-labelled plastic containers to each class for the children to take home and use to collect a stool sample. These plastic containers were returned to the research assistant in the morning of the following day. To reduce discomfort, paper bags were provided along with the containers. All stool samples were processed on the day of collection at the study site. We used Kato-Katz technique to detect parasitic infections with regard to the three main soil-transmitted helminths (Ascaris lumbricoides, hookworm and Trichuris trichiura), and Schistosoma mansoni. Stool samples (at least 10–15 g) were first visually examined for the presence of blood, mucus and diarrhoea. Thereafter, duplicate 41.7 mg Kato-Katz thick smears were prepared from each stool sample, and a random sample of 10% of the Kato-Katz slides was re-examined by a senior technician for quality control. In case of discordant results, the slides were read a third time, and the results discussed among the technicians until agreement was reached.

***Figure 07.01*** Prevalence of disease symptoms and use of medication in the total sample

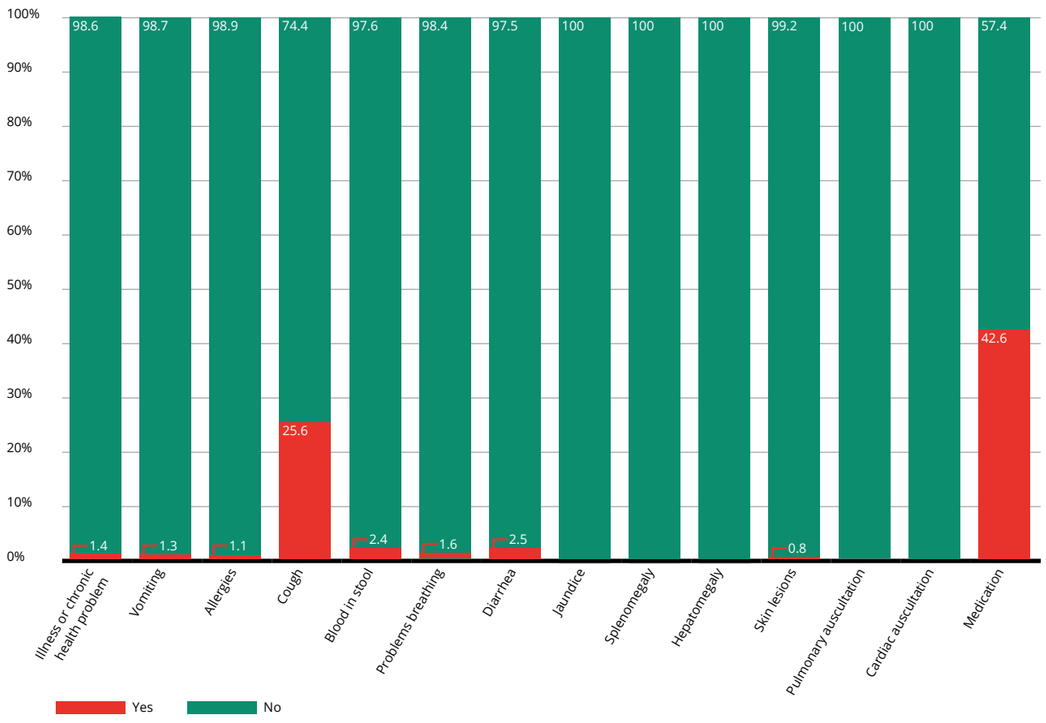
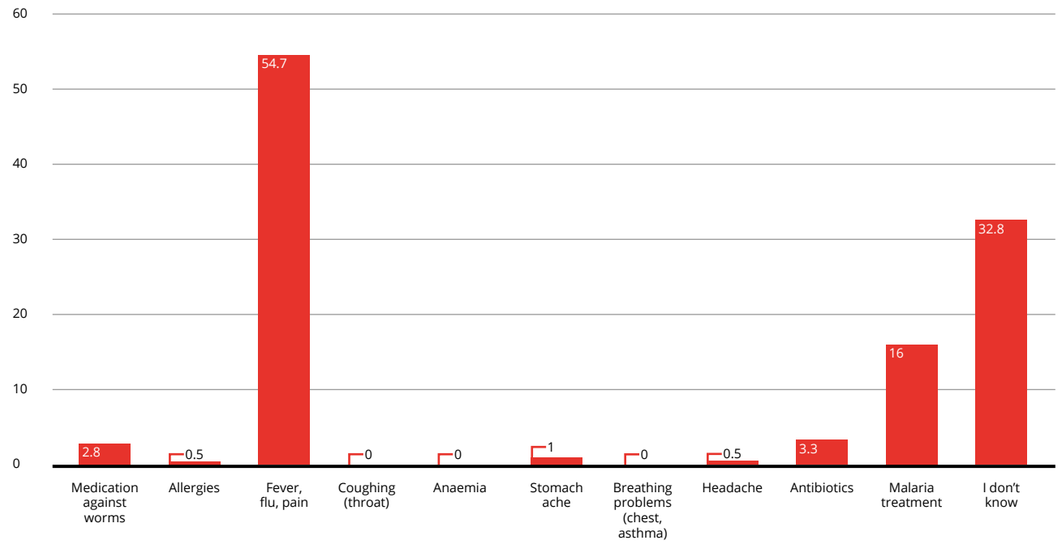





***Figure 07.02*** Type of medication




## *Results*

In total, 923 children participated in the clinical examination. Figure 07.01 provides an overview of the most prevalent disease symptoms. In total, 1.4% of the children reported that they had a chronic illness or health problem. Moreover, 25.6% of the children had a cough, whereas other symptoms were rare (<10%). More specifically, 2.5% had diarrhea, 2.4 had blood in stool, 1.6% reported breathing problems, 1.3% reported nausea/vomiting and 1.1% had allergies. Jaundice, splenomegaly, hepatomegaly as well as pulmonary and cardiac auscultations were not found in the present sample of children. Similarly, skin lesions (0.8%) were very rare. Somewhat surprisingly, more than 40% of the children (42.6%) reported that they were taking a medication during the past week. As shown in Figure 07.02, among those children who took medication during the past week, the majority took medication against fever, flu or pain (e.g., paracetamol) (54.7%), followed by medication for the treatment against malaria (e.g., ALU) (16.0%). Less frequently reported was medication against worms (2.8%), stomach ache (1.0%), allergies (0.5%), and headache (0.5%). 3.3% of the children reported that they would currently taking antibiotics. Interestingly, a relatively large percentage of children did not know what kind of medication they were taking (32.8%).

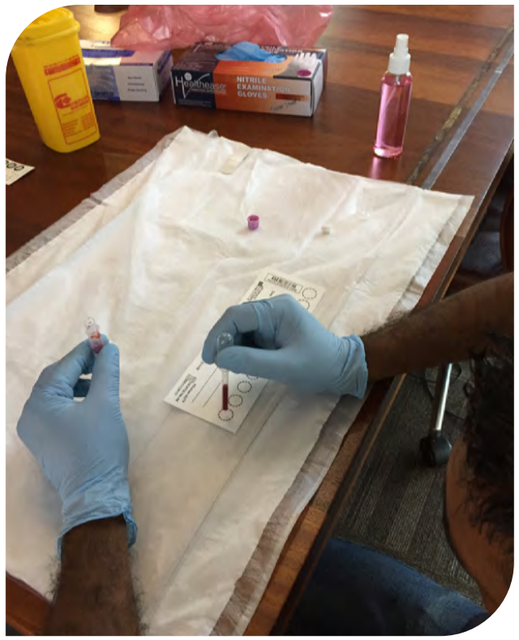
A comparison between boys and girls (Table 07.01) showed that disease symptoms were similar among boys and girls as well as younger and older learners. The only statistically significant difference between was found in the sense that grade 4 learners reported a lower medication intake than peers from the grade 1 to grade 3.

With regard to anaemic status, the majority of the children were classified as non-anaemic (88.1%), whereas 7.1% presented with mild, 4.5% with moderate and 0.2% with severe anaemia (Figure 07.03). No statistically significant differences were found between boys and girls as well as learners from earlier and more advanced grades.

***Table 07.01*** Disease symptoms and use of medication, separately for boys and girls and learners attending different grades

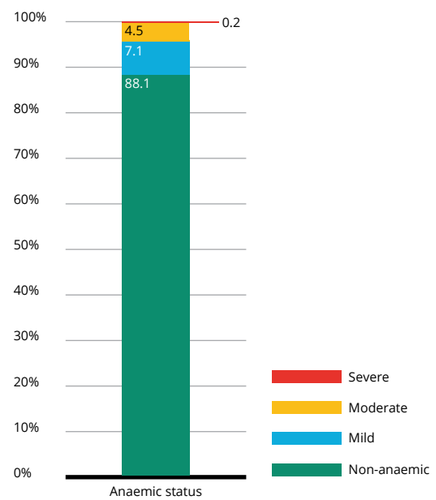
| | Total sample | | Boys | | Girls | | Grade 1 | | Grade 2 | | Grade 3 | | Grade 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *n* | % | *n* | % | *n* | % | *n* | % | *n* | % | *n* | % | *n* | % |
| ***Vomitting*** | 12 | 1.3 | 9 | 2.0 | 3 | 0.6 | 3 | 1.5 | 4 | 1.9 | 3 | 1.1 | 2 | 0.9 |
| ***Allergies*** | 10 | 1.1 | 4 | 0.9 | 6 | 1.3 | 1 | 0.5 | 3 | 1.5 | 4 | 1.4 | 2 | 0.9 |
| ***Cough*** | 235 | 25.6 | 104 | 23.5 | 131 | 27.5 | 61 | 30.0 | 57 | 27.7 | 73 | 26.9 | 45 | 19.2 |
| ***Blood in stool*** | 22 | 2.4 | 13 | 2.9 | 9 | 1.9 | 9 | 4.4 | 6 | 2.9 | 4 | 1.4 | 3 | 1.3 |
| ***Problems breathing*** | 15 | 1.6 | 6 | 1.4 | 9 | 1.9 | 6 | 3.0 | 3 | 1.5 | 5 | 1.8 | 1 | 0.4 |
| ***Diarrhea*** | 23 | 2.5 | 14 | 3.2 | 9 | 1.9 | 2 | 1.0 | 9 | 4.4 | 11 | 4.0 | 1 | 0.4 |
| ***Jaundice*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Splenomegaly*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Hepatomegaly*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Skin lesions*** | 7 | 0.8 | 4 | 0.9 | 3 | 0.6 | 1 | 0.5 | 2 | 1.0 | 1 | 0.4 | 4 | 1.3 |
| ***Pulmonary auscultation*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Cardiac auscultation*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Medication*** | 391 | 42.6 | 192 | 43.4 | 199 | 41.8 | 104 | 51.9 | 108 | 52.4 | 106 | 38.1 | 75 | 31.9 |

▲ Blood workshop with the team




▲ Dried blood spot

***Figure 07.03*** Prevalence of mild, moderate and severe anaemia in the total sample (in %)




## *Conclusion*

In summary, it can be stated that in line with the generally positive health perception of the children, few disease symptoms were reported/identified within the framework of the clinical examinations. The most frequently observed symptom was cough (25.6%), whereas the prevalence of all other symptoms (e.g., diarrhea, breathing difficulties, allergies and skin lesions) was below 3%. In contrast, more than four of ten children stated that they have taken medication in the last week. Medicines for fever, pain and flu and for malaria treatment were particularly widespread. Almost one third of the children did not know what they were taking medication for. Moderate or severe anaemia was found in 4.7% of the children.

# *Growth and body composition*

08

## *Background*

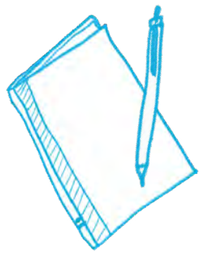
Worldwide, there are serious concerns regarding the increase in overweight and obesity of children and adolescents, especially in urbanised populations and economically developed countries (de Onis & Blössner, 2000; Wang & Lobstein, 2006). Already at pre-school age, the prevalence of overweight and obese children has increased steadily during the past decades (de Onis et al., 2010). At a global scale, the prevalence of obesity increased at an alarming rate from 0.9% in girls and 0.7% in boys in 1975 to 7.8% in girls and 5.6% in boys in 2016 (Blüher, 2019). However, childhood overweight and obesity have also increased in developing nations due to the nutrition transition (Armstrong et al., 2011). The estimated childhood prevalence of overweight/obesity in Africa was 8.5% in 2010 and was expected to be 12.7% in 2020. This is a significant increase given that the prevalence was only 4.0% in 1990 (de Onis et al., 2010). Moreover, the increase in childhood overweight/obesity is expected to be markedly higher in Africa compared to Asia or high-income countries (Mokabane et al., 2014). Importantly, approximately three of four overweight children aged less than 5 years live in low-to-middle income countries (Black et al., 2013). From a public health perspective, these figures are alarming given that overweight/obese children have a markedly higher clustered cardiovascular risk (Nyberg et al., 2011; Sardinha et al., 2016).

***The increase in childhood overweight/ obesity is expected to be markedly higher in Africa compared to Asia or high-income countries.***

The WHO defines children as stunted if their height-for-age is two standard deviations below the WHO child growth standards median (de Onis, 2007). Therefore, linear growth is an important indicator of children's nutritional status and healthy development. In school-aged children, stunted children are at increased risk of having higher school absenteeism and dropout rates, and of underperforming academically (Ezeamama et al., 2018; Liu et al., 2015). Moreover, for reasons that are still poorly understood, stunting seems to be more prevalent among boys than girls, particularly in the lower socioeconomic strata (Wamani et al., 2007).

▲ Girls at school

***For reasons that are still poorly understood, stunting seems to be more prevalent among boys than girls, particularly in the lower socioeconomic strata.***



▲ Children at school



## *How did we assess growth and body composition?*

We assessed children's body composition via bioelectrical impedance analysis (BIA) with a wireless body composition monitor (Tanita MC-580, Tanita Corp.; Tokyo, Japan). We asked the participants to fast for 3 h before the data assessment, to void their bladder immediately before the assessment, and to wear only light clothing (≤1 kg). We also used the MC-580 to assess body weight, which was measured to the nearest 0.1 kg. With shoes off, each child stood against a stadiometer with the back erect and shoulders relaxed. Body height was taken to the nearest 0.1 cm. Sex-specific height or length-for-age and weight-for-age z-scores were computed from the CDC/WHO growth reference data (Ogden et al., 2002).

▲ Start of a physical education class

## Results

At baseline, BMI was assessed in 990 children. The mean BMI was 16.12 kg/m$^2$ (Table 08.01). Whereas boys and girls did not significantly differ with regard to their BMI, BMI scores were higher in learners attending more advanced grades. In 761 children, BMI was assessed across all measurement timepoints. As shown in Figure 08.01, average BMI increased from T1 to T3, with a statically significantly higher increase in girls compared to boys.

Information on weight status was available for 990 children. As shown in Figure 08.02, 4.6% of the learners were classified as underweight, 82.6% as normal weight, 10.7% as overweight and 2.0% as obese. As shown in Table 08.02, no statistically significant differences occurred between boys and girls. In contrast, boys were overrepresented among normal weight children. With regard to grade level, no clear pattern emerged. As shown in Table 08.02, learners from grade 2 were overrepresented among overweight children.

Information on wasting and stunting was available for 710 and 990 children, respectively. As shown in Figure 08.03, 3.9% of the children were classified as wasted, whereas the percentage of stunted children amounted to 13.6%. Girls (3.6%) and boys (4.2%) had similar risks for wasting (Table 08.02). Similarly, no

***BMI was assessed in***

**923**

***children.***

significant sex differences were found with regard to stunting. Grade level was unrelated to wasting, whereas the risk of stunting was lower among grade 2 learners.

Body composition was assessed in 939 children. At baseline, the mean weight of the children was 27.19 kg and the mean height 129.13 cm (Table 08.01). While boys and girls did not differ with regard to body weight, boys were slightly taller. Expectedly, body weight and height were significantly higher in learners from more advanced grades (grade 1: 21.69 kg, 118.30 cm; grade 4: 31.32 kg, 137.93 cm). As shown in Table 08.01, mean body fat at baseline was 20.30% in the total sample, and 18.43% in boys and 22.01% in girls. Relative and absolute body fat was significantly higher in girls than boys. By contrast, boys had higher relative and absolute muscle mass, higher absolute bone mass, absolute fat free mass, and total body water. Boys also had a significantly higher basal metabolic rate than girls. Absolute and relative fat mass was higher among students from more advanced grades. Absolute muscle mass also increased from grade 1 (16.10 kg) to grade 4 (23.81 kg), which was also true for absolute bone mass (increase from 0.97 kg to 1.36 kg), fat-free mass (from 17.06 kg to 25.16 kg), total body water (from 12.51 kg to 18.43 kg), and basal metabolic rate (from 4186 KJ to 4822 KJ).

Data on body composition was available for 720 children across all measurement timepoints. The body weight and body height increased similarly in boys and girls from T1 to T3. As shown in Figure 08.04, sex differences in relative body fat became more substantial from T2 to T3. A similar pattern was also observed for absolute body fat, whereas differences in muscle mass, fat free mass, body water and basal metabolic rate (KJ) remained relatively stable across time, with boys having higher values than girls across all measurement timepoints (data not shown).

***Figure 08.01*** Development of BMI (kg/m$^2$) across the study period, for the total sample and separately for boys and girls

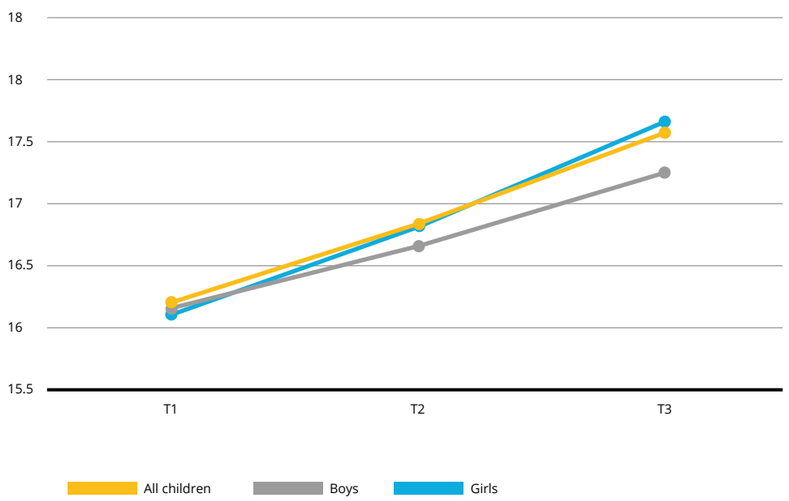





***Table 08.01*** Growth, body composition, and basal metabolic rate, separately for boys and girls and learners attending different grades

| | Total sample | | Boys | | Girls | | Grade 1 | | Grade 2 | | Grade 3 | | Grade 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| ***BMI (kg/m²)*** | 16.12 | 1.95 | 16.02 | 1.80 | 16.07 | 1.98 | 15.48 | 1.68 | 15.87 | 1.56 | 16.29 | 2.03 | 16.36 | 2.01 |
| ***Weight (kg)*** | 27.19 | 6.34 | 27.08 | 5.51 | 26.43 | 6.10 | 21.74 | 3.65 | 24.16 | 3.48 | 28.20 | 4.83 | 31.32 | 5.77 |
| ***Height (cm)*** | 129.13 | 10.69 | 129.53 | 10.20 | 127.52 | 10.19 | 118.35 | 7.10 | 123.21 | 6.75 | 131.35 | 7.43 | 137.93 | 7.44 |
| ***Body fat (%)*** | 20.30 | 3.94 | 18.43 | 3.79 | 22.01 | 3.25 | 21.27 | 3.07 | 20.93 | 3.30 | 19.99 | 4.34 | 19.33 | 4.30 |
| ***Body fat (kg)*** | 5.46 | 1.87 | 4.99 | 1.63 | 5.88 | 1.98 | 4.62 | 1.05 | 5.08 | 1.24 | 5.70 | 2.04 | 6.15 | 2.26 |
| ***Muscle mass (%)*** | 75.31 | 3.67 | 76.90 | 3.61 | 73.85 | 3.06 | 74.27 | 2.86 | 74.67 | 3.02 | 75.65 | 4.03 | 76.30 | 3.96 |
| ***Muscle mass (kg)*** | 20.11 | 4.36 | 20.82 | 4.39 | 19.46 | 4.24 | 16.10 | 2.76 | 18.01 | 2.53 | 21.27 | 3.39 | 23.81 | 4.03 |
| ***Bone mass (kg)*** | 1.17 | 0.23 | 1.26 | 0.22 | 1.09 | 0.22 | 0.97 | 0.16 | 1.07 | 0.15 | 1.23 | 0.19 | 1.36 | 0.21 |
| ***Fat-free mass (kg)*** | 21.28 | 4.59 | 22.08 | 4.60 | 20.55 | 4.46 | 17.06 | 2.91 | 19.08 | 2.68 | 22.50 | 3.57 | 25.16 | 4.24 |
| ***Body water (kg)*** | 15.58 | 3.38 | 16.17 | 3.41 | 15.04 | 3.26 | 12.51 | 2.23 | 13.97 | 1.96 | 16.47 | 2.62 | 18.43 | 3.14 |
| ***Basal metabolic rate (KJ)*** | 4515 | 499 | 4848 | 395 | 4210 | 374 | 4186 | 366 | 4342 | 395 | 4609 | 464 | 4821 | 501 |

***Figure 08.02*** Prevalence of normal weight, underweight, overweight and obesity (in %)

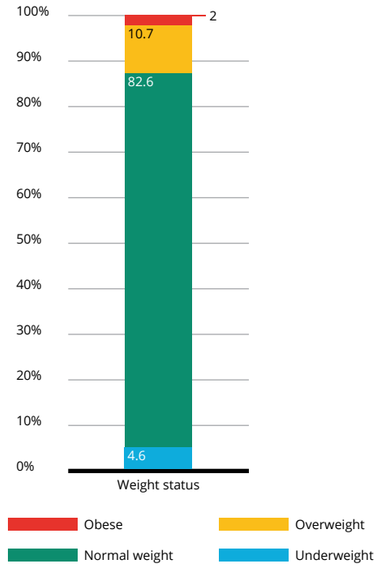



***Figure 08.03*** Prevalence of stunting and wasting (in %)

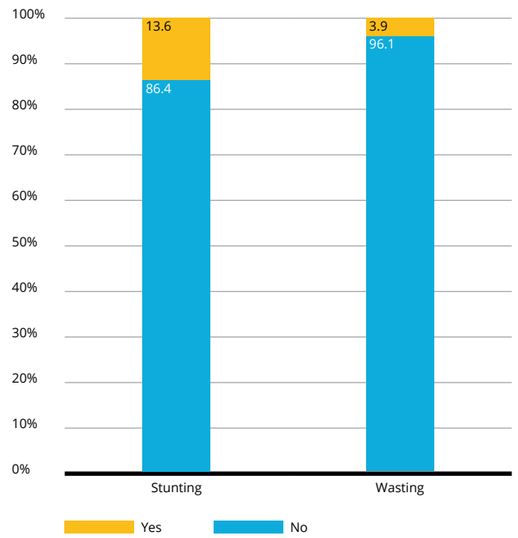


***Table 08.02*** Weight status, separately for boys and girls and learners attending different grades

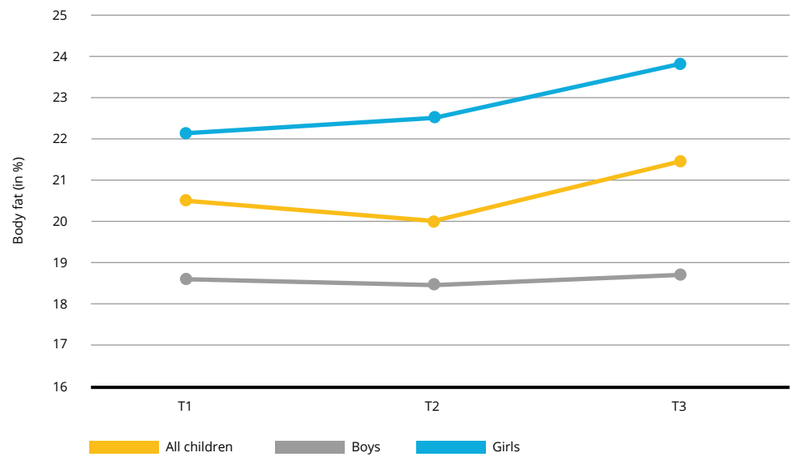
| | *Total sample* | | *Boys* | | *Girls* | | *Grade 1* | | *Grade 2* | | *Grade 3* | | *Grade 4* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *n* | *%* | *n* | *%* | *n* | *%* | *n* | *%* | *n* | *%* | *n* | *%* | *n* | *%* |
| ***Underweight*** | 46 | 4.6 | 28 | 6.3 | 14 | 2.9 | 8 | 4.0 | 4 | 2.0 | 11 | 3.7 | 19 | 8.0 |
| ***Normal weight*** | 818 | 82.6 | 363 | 81.2 | 411 | 84.0 | 171 | 84.7 | 154 | 76.6 | 251 | 84.5 | 201 | 84.5 |
| ***Overweight*** | 106 | 10.7 | 49 | 11.0 | 52 | 10.6 | 19 | 9.4 | 40 | 19.9 | 26 | 8.8 | 15 | 6.3 |
| ***Obese*** | 20 | 2.0 | 7 | 1.6 | 12 | 2.5 | 4 | 2.0 | 3 | 1.5 | 9 | 3.0 | 3 | 1.3 |
| ***Stunted*** | 135 | 13.6 | 60 | 13.4 | 60 | 12.3 | 31 | 15.3 | 10 | 5.0 | 37 | 12.5 | 42 | 17.6 |
| ***Wasted*** | 28 | 3.9 | 13 | 4.2 | 14 | 3.6 | 9 | 4.5 | 3 | 1.5 | 11 | 5.1 | 4 | 4.5 |

Note: For wasting, data was available only for 710 children.

▲ Lining up for physical education

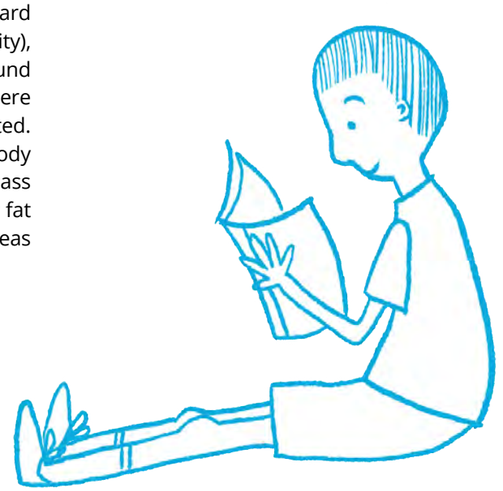


***Figure 08.04*** Development of body fat across the study period, for the total sample and separately for boys and girls




## *Conclusion*

On average, an increase was found for BMI from T1 to T3, which was more marked in girls compared to boys. In total, 5% of the children were classified as underweight, 83% as normal weight, 11% as overweight and 2% as obese. Based on these findings, we can conclude that overnutrition is a more prevalent health issue in this sample than undernutrition. With regard to weight status (underweight, overweight/obesity), wasting and stunting, similar prevalences were found for boys and girls. In total, 4% of the children were classified as wasted, whereas 14% were stunted. Whereas girls had higher relative and absolute body fat than boys, boys had higher relative muscle mass and basal metabolic rate than girls. Relative body fat increased significantly among girls over time, whereas values remained stable in boys.



# *Cardiovascular risk factors*

## *Background*

On a global level, non-communicable diseases are the leading causes of death and disability (WHO., 2015), and cardiovascular diseases often have their origin in childhood (Berenson et al., 1998). Studies have shown that children who present with cardiovascular disease risk factors are at higher risk for fatty streaks and fibrous plaques, for artery calcification, and for common artery intima media thickness in adulthood (Mahoney et al., 1996; Raitakari et al., 2003). As a consequence, early screening for cardiometabolic complications is considered important both from a clinical and public health perspective (Magnussen et al., 2012; Sardinha et al., 2016). Developing countries are faced with a double disease burden, with non-communicable diseases adding to a persistent high burden of infections (Assah et al., 2015). This is critical as healthcare resources are limited in these countries. Thus, although communicable diseases will remain a predominant health issue in Sub-Saharan Africa, concerns have been raised regarding the rapid increase of non-communicable diseases such as hypertension, heart disease, diabetes, particularly in more urbanized settings (Unwin et al., 2001). Blood pressure, total cholesterol, high-density lipoprotein cholesterol (HDL), triglycerides, insulin, glucose, and body fat have been identified as the most recognised cardiovascular disease risk factors among children and adolescents (Ruiz et al., 2016). Moreover, previous research showed that exercise training intervention with children and adolescents can have a positive impact on cardiovascular risk factors, as long as they are sufficiently long and take place on a regular basis (Mountjoy et al., 2011).

***Developing countries are faced with a double disease burden, with non-communicable diseases adding to a persistently high burden of infections. This is critical as healthcare resources are limited in these countries.***

## *Which cardiovascular risk factors did we assess?*

For the detection of hypertension, we measured blood pressure of each child three times within 3 min while the child was seated for 5 min with the Omron® digital blood pressure monitor. A cuff-size appropriate to the arm-circumference of the child was chosen. For the assessment of blood lipid profiles (total cholesterol [TC], low-density-lipoprotein cholesterol [LDL-C], high-density-lipoprotein cholesterol [HDL-C], and triglycerides [TG], we analysed capillary samples for blood lipid by Alere Technologies. One drop of blood was taken up by the test strip and read by the machine. For the measurement of glycated haemoglobin (HbA1c) level, we used a point-of-care instrument employing the Afinion test (Alere Technologies). Of note, the HbA1c level reflects the average plasma glucose concentration levels over the previous 8-12 weeks before measurement with no prior fasting required. We also used finger prick technique to determine children's micronutrient status/deficiencies (concentrations of Vitamin A, Vitamin D, iron zinc; see chapter 13).

***Figure 09.01*** Prevalence of hypertension in the total sample (in %)

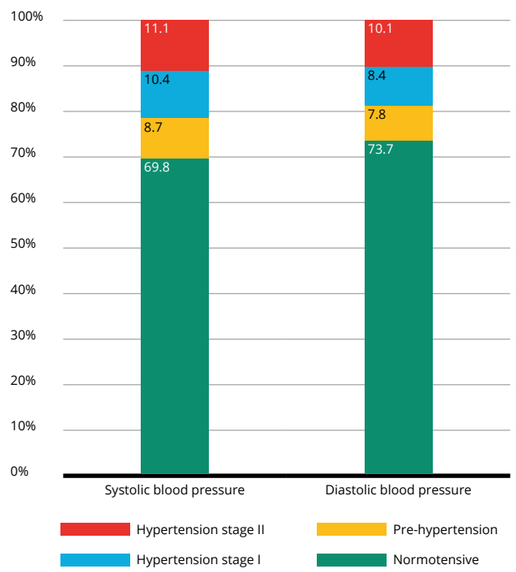



***Table 09.01*** Cardiovascular risk factors, separately for boys and girls and learners from different grades

| | Total sample | | Boys | | Girls | | Grade 1 | | Grade 2 | | Grade 3 | | Grade 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| ***Systolic blood pressure*** | 103.16 | 10.89 | 103.67 | 10.73 | 102.69 | 11.03 | 101.47 | 10.48 | 100.22 | 10.52 | 104.43 | 10.97 | 105.71 | 10.61 |
| ***Diastolic blood pressure*** | 66.11 | 8.63 | 66.23 | 8.26 | 66.00 | 8.96 | 3.70 | 0.67 | 3.75 | 0.66 | 3.75 | 0.66 | 3.82 | 0.63 |
| ***Total cholesterol*** | 3.76 | 0.65 | 3.67 | 0.62 | 3.84 | 0.68 | 3.70 | 0.67 | 3.75 | 0.66 | 3.75 | 0.66 | 3.82 | 0.63 |
| ***LDL cholesterol*** | 2.16 | 0.54 | 2.10 | 0.52 | 2.21 | 0.56 | 2.16 | 0.54 | 2.21 | 0.51 | 2.14 | 0.57 | 2.13 | 0.53 |
| ***HDL cholesterol*** | 1.26 | 0.35 | 1.23 | 0.32 | 1.29 | 0.37 | 1.23 | 0.34 | 1.23 | 0.38 | 1.27 | 0.35 | 1.32 | 0.31 |
| ***Triglycerides*** | 0.78 | 0.34 | 0.78 | 0.33 | 0.77 | 0.34 | 0.73 | 0.26 | 0.74 | 0.28 | 0.77 | 0.32 | 0.85 | 0.45 |
| ***Blood glucose (Hba1c)*** | 5.16 | 0.31 | 5.15 | 0.34 | 5.16 | 0.29 | 5.17 | 0.30 | 5.13 | 0.34 | 5.17 | 0.3 | 5.15 | 0.32 |



***Figure 09.02A*** Development of blood pressure across the study period for systolic blood pressure (in mm Hg), for the total sample and separately for boys and girls

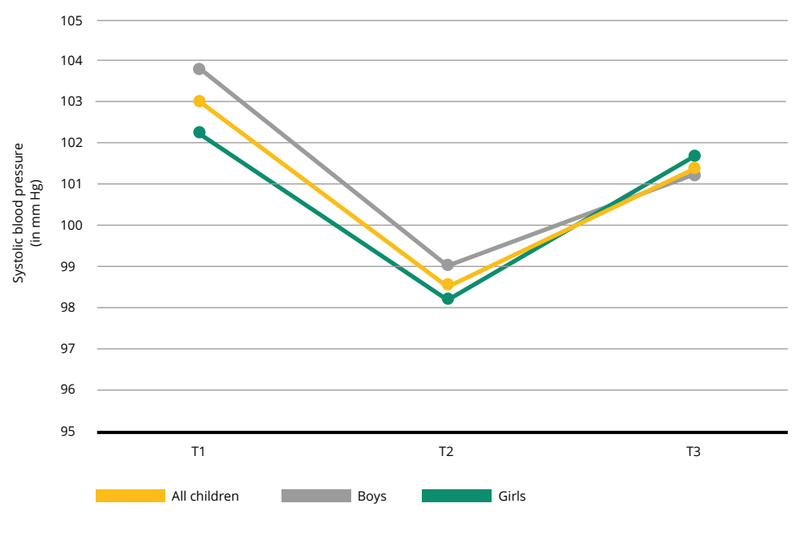
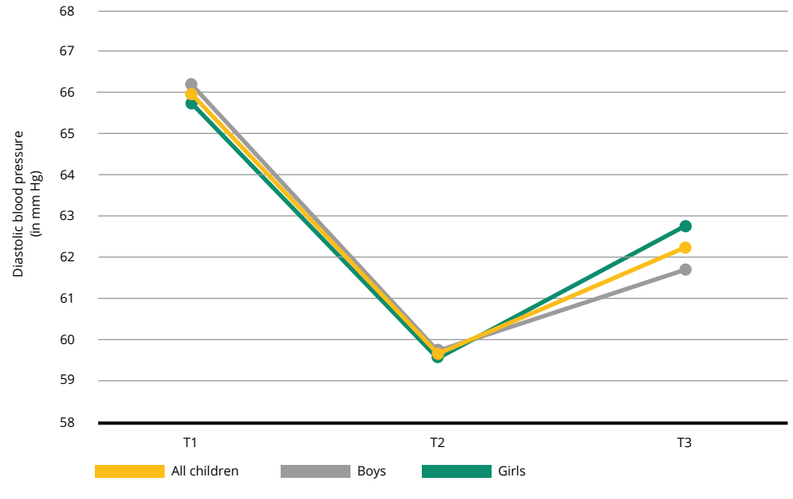



***Figure 09.02B*** Development of blood pressure across the study period for diastolic blood pressure (in mm Hg), for the total sample and separately for boys and girls

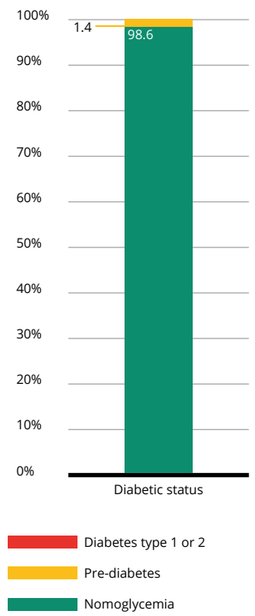


## Results

In total, 919 children had valid blood pressure data. As shown in Figure 09.01, based on systolic blood pressure, 69.8% of the children were classified as normotensive, 8.7% as pre-hypertensive, and 21.5% as hypertensive (10.4% stage I, 11.1% stage II). Based on diastolic blood pressure, the percentage of normotensive children was slightly higher (73.7%). The percentage of normotensive children was similar in boys (systolic: 71.9%, diastolic: 76.4%) and girls (systolic: 68.3%, diastolic: 71.6%). Average baseline blood pressure for the total sample, boys vs. girls and different grade levels are shown in Table 09.01. A total of 755 children had valid blood pressure data across all measurement time points. These data show that for both systolic and diastolic blood pressure, a decrease occurred between T1 and T2, whereas values increased again from T2 to T3 (Figure 09.02A/B).

In those 917 children with valid baseline data on blood glucose (HbA1c), 96.8% were classified as normoglycemic, whereas 1.4% presented with pre-diabetes. None of the learners was classified as diabetic (Figure 09.03). The percentage of pre-diabetic children was similar in boys (1.6%) and girls (1.3%) and learners from different grades. As shown in Figure 09.04, HbA1c levels increased from T1 to T2, and remained relatively stable from T2 to T3.

***Figure 09.03*** Diabetic status




▲ Children participating in a moving-to-music class



***Figure 09.04*** Development of HbA1c across the study period, for the total sample and separately for boys and girls

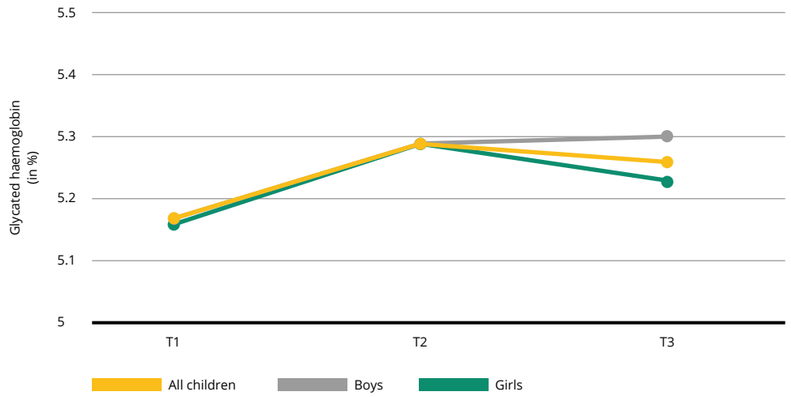
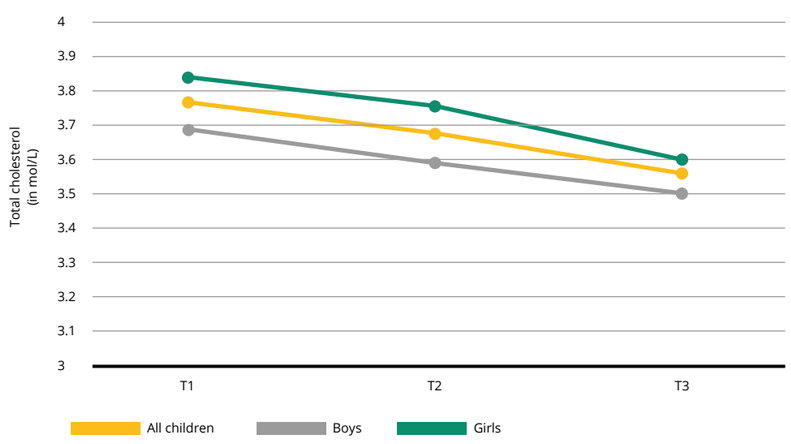



***Figure 09.05A*** Development of total cholesterol across the study period, for the total sample and separately for boys and girls




***In those 917 children with valid baseline data on blood glucose (HbA1c), 96.8% were classified as normoglycemic, whereas 1.4% presented with pre-diabetes.***

***Figure 09.05B*** Development of low density lipoprotein across the study period, for the total sample and separately for boys and girls

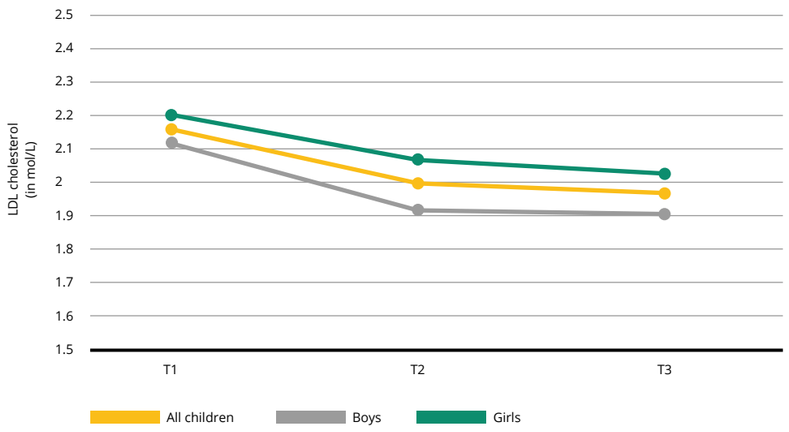



***Figure 09.05C*** Development of high-density lipoprotein across the study period, for the total sample and separately for boys and girls

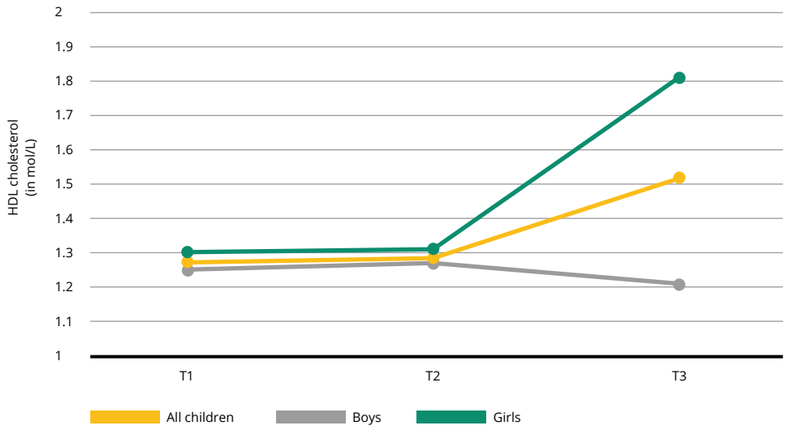
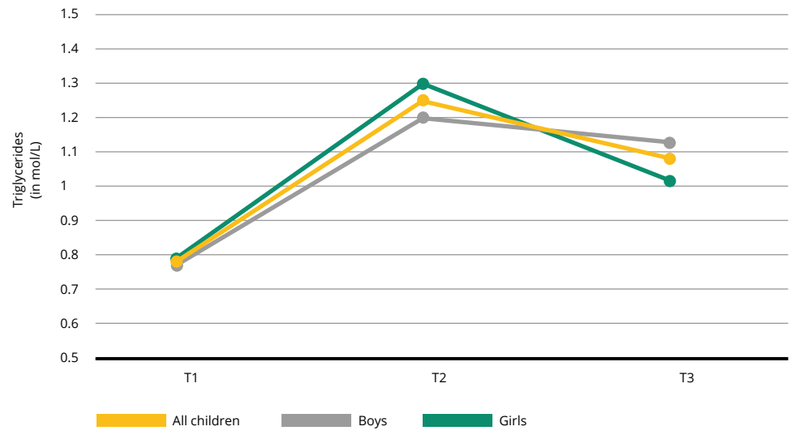





***Figure 09.05D*** Development of Triglycerides across the study period, for the total sample and separately for boys and girls




Depending on the specific outcome, between 801 and 819 children had valid baseline data for blood lipids. Mean scores are shown in Table 09.01, separately for boys and girls, and children from different grades. Girls had significantly higher values for total cholesterol, LDL cholesterol, and HDL cholesterol. No significant differences were found for triglycerides. Triglyceride concentration was lower among grade 1-2 learners compared to grade 3–4 learners. Otherwise, no statistically significant differences were found between learners from different school grades. Across all measurement time points, 479 children had valid total cholesterol data. The course over time is shown in Figure 09.05A, pointing towards a decrease from T1 to T3. A similar pattern was found for LDL cholesterol (Figure 09.05B), whereas HDL cholesterol was stable between T1 and T2, and then increased in girls (Figure 09.05C). For triglycerides, an increase occurred from T1 to T2, followed by a stabilization (boys) or a slight decrease (girls) (Figure 09.05D).

## *Conclusion*

Hypertension appears to be an important cardiovascular risk factor in Tanzanian children. Between 18-22% of the children were classified as hypertensive. Diabetes was diagnosed in none of the children, and few of them were identified as pre-diabetic. It is positive to note that total cholesterol and LDL cholesterol levels decreased over the course of the study, while HDL cholesterol levels increased (at least in girls). The increase in triglycerides, on the other hand, is critical. With regard to the development over time, there were only few differences between boys and girls.

# *Sleep and sleep environment*





## *Background*

For several reasons, sleep is key for children's health and development (Schlieber & Han, 2021). First, sleep can impact growth and development. Thus, during sleep, the body produces growth hormones, which are crucial for the growth and development of children (Verrillo et al., 2011). In addition, adequate sleep supports the growth of bones, muscles and organs (Casazza et al., 2011; Lamon et al., 2021). Second, sleep has the potential to strengthen children's immune system (Garbarino et al., 2021). During sleep, immune cells are produced that fight infection and protect the child from disease. Third, sleep has important influence on brain development (Yang et al., 2022). During sleep, memories are processed and the brain regenerates. Adequate sleep improves cognitive function, learning, concentration and attention span (Lokhandwala & Spencer, 2022). Fourth, a lack of sleep can lead to emotional issues such as irritability, depressed mood or anxiety (Asarnow & Mirchandaney, 2021). Adequate sleep helps children better regulate their emotions and maintain positive mental well-being. Fifth, children who get enough sleep have more energy and are more active during the day (Ahmadi & Omidvar, 2022; Lang et al., 2016). Good sleep improves physical performance, coordination and motor skills (Manacero & Nunes, 2021). Therefore, parents should ensure that their children get enough sleep and provide conducive sleep environments. The recommended amount of sleep varies by age, but in general, preschoolers need about 10-13 hours of sleep per night, while the recommended sleep duration is 9-12 hours for older school-aged children (Paruthi et al., 2016).

## *How did we measure sleep and sleep environment?*

To assess sleep quality, we applied several (adapted) questions from the Pittsburgh Sleep Quality Index (PSQI). To screen for sleep disturbances, three items of the Insomnia Severity Index asked about difficulty falling asleep, staying asleep and waking up too early in the morning. To assess further information about sleep quality and daytime functioning, we invited children to rate their overall sleep quality and to report how restored they feel in the morning, how tired they feel during the day and how exhausted they feel in the evening. Children also provided basic information about their sleep environment (e.g., room, type of bed, and people sleeping in the same room/bed). To gather information about children's sleep pattern, we asked parents/guardians to report the time at which their child goes to bed and wakes up in the morning on school nights and school days.

## *Results*

916 children had valid data for self-reported sleep complaints. As shown in Figure 10.01, the number of children who reported single symptoms of sleep complaints on a regular basis varied between 3.1% (feeling very tired at bedtime) and 22.5% (not feeling restored in the morning). About every sixth child (17.0%) reported problems falling asleep at night, whereas 7.1% reported frequent awakenings during the night. As shown in Table 10.01, few differences were found between boys and girls. The only statistically significant difference was that boys felt more restored/fit in the morning than girls. Problems falling asleep decreased statistically significantly from grade 1 to grade 4. Otherwise, no differences were observed between learners from different grades.

Information about the sleep environment of the children is provided in Figure 10.02, showing that only 12.3% of the children sleep in their own room. 4.8% of the children sleep on a mattress on the floor, 23.7% in a single bed and 65.9% in a double bed. 67.9% of the children share the bed with someone. Additionally, 57.5% of the children indicated that their bedroom was also used for cooking and living. The majority of the children indicated that they slept under a mosquito net (97.6%).

Based on 843 parental reports, most of the children go to bed between 7–9 pm on both weekdays and weekend days (Figure 10.03A). During weekdays, most of the students get up between 6–7 am (63.8%). About one third of the learners get up before 6 am (31.2%). During weekend day, most of the children get up between 6–7 am (31.2%) and 7–8 am (58.5%) (Figure 10.03B). No differences were found with regard to the sex of the children. However, older children tended to go to bed later during both weekday nights (Figure 10.03C) and weekend nights (Figure 10.03D). By contrast, wake-up times did not differ between children from different grades, neither during weekdays nor on weekends.

As shown in Figure 10.04, the number of sleep complaints reported by the children of the present sample decreased from baseline to follow-up, particularly between T1 and T2. This pattern was similar in boys and girls.

***Sleep can impact growth and development. Thus, during sleep, the body produces growth hormones, which are crucisl for the growth and development of children.***

***Figure 10.01*** Prevalence of children reporting different symptoms of sleep complaints in the total sample (in %)

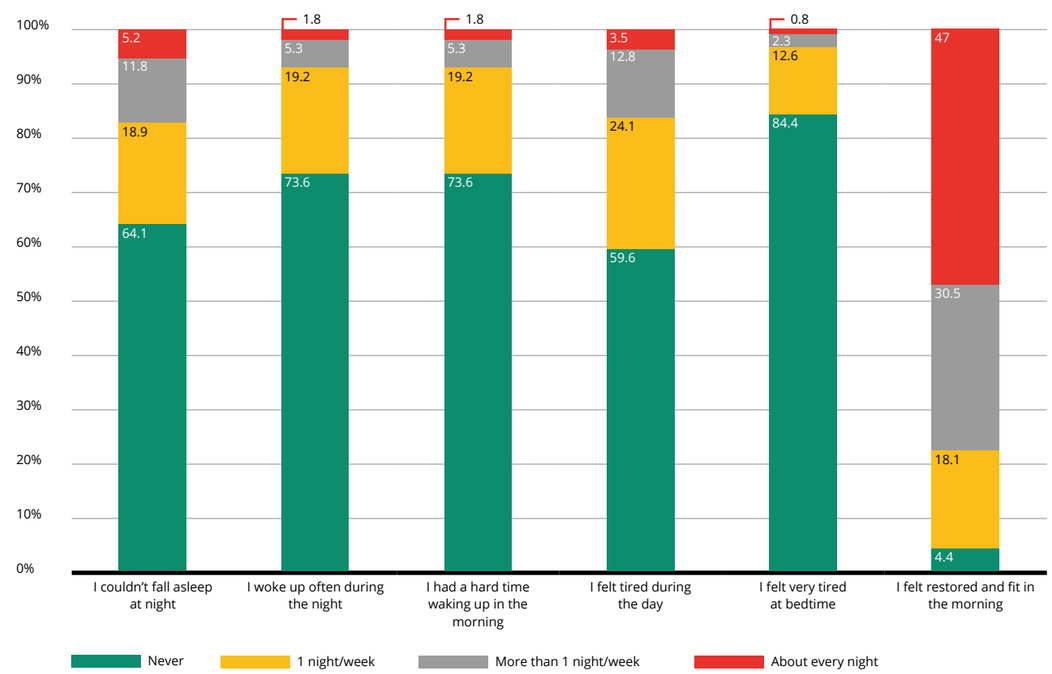
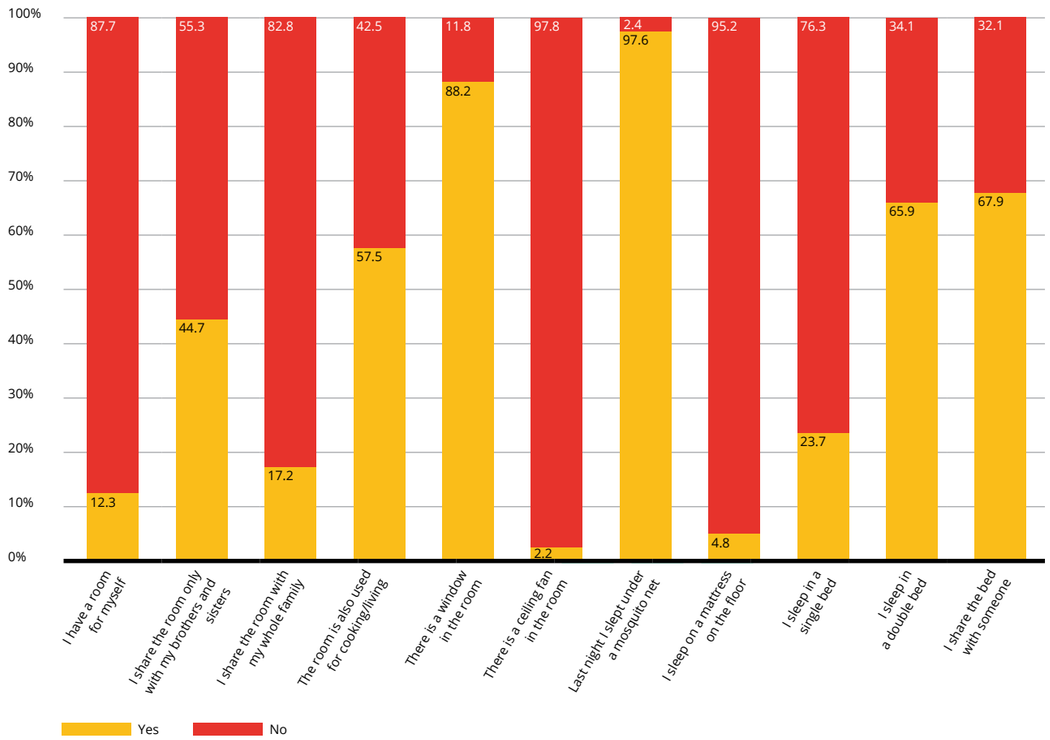



***Table 10.01*** Sleep quality, separately for boys and girls and learners attending different grades

| | *Total sample* | | *Boys* | | *Girls* | | *Grade 1* | | *Grade 2* | | *Grade 3* | | *Grade 4* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| *Child self-report* | | | | | | | | | | | | | | |
| ***I couldn't fall asleep at night.*** | 1.59 | 0.89 | 1.62 | 0.92 | 1.56 | 0.87 | 1.75 | 0.95 | 1.67 | 0.89 | 1.64 | 0.96 | 1.30 | 0.68 |
| ***I woke up often during the night.*** | 1.39 | 0.61 | 1.36 | 0.59 | 1.43 | 0.62 | 1.43 | 0.56 | 1.38 | 0.56 | 1.44 | 0.67 | 1.31 | 0.59 |
| ***I had a hard time waking up in the morning.*** | 1.36 | 0.68 | 1.37 | 0.67 | 1.35 | 0.68 | 1.43 | 0.66 | 1.36 | 0.67 | 1.35 | 0.73 | 1.30 | 0.62 |
| ***I felt tired during the day.*** | 1.60 | 0.84 | 1.61 | 0.86 | 1.59 | 0.83 | 1.51 | 0.68 | 1.59 | 0.84 | 1.68 | 0.93 | 1.60 | 0.87 |
| ***I felt very tired at bedtime.*** | 1.19 | 0.50 | 1.18 | 0.48 | 1.21 | 0.53 | 1.23 | 0.46 | 1.14 | 0.39 | 1.23 | 0.62 | 1.18 | 0.48 |
| ***I felt restored and fit in the morning.*** | 3.32 | 1.04 | 3.41 | 1.02 | 3.24 | 1.06 | 3.23 | 0.90 | 3.30 | 0.97 | 3.40 | 1.05 | 3.34 | 1.21 |
| ***How has your sleep been?*** | 3.86 | 0.86 | 3.87 | 0.87 | 3.85 | 0.85 | 3.83 | 0.85 | 3.87 | 0.86 | 3.81 | 0.91 | 3.92 | 0.81 |

## *About every sixth child (17.0%) reported problems falling asleep at night, whereas 7.1% reported frequent awakenings during the night.*

***Figure 10.02*** Characteristics of the sleep environment across the total sample (in %)



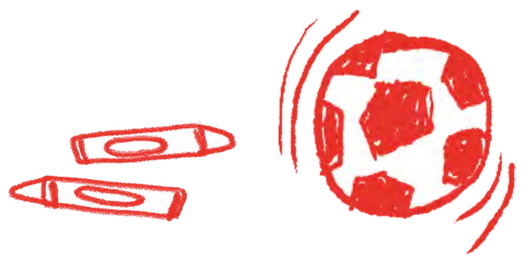





***Figure 10.03A*** Percentage of children with different bedtimes during weekday and weekend nights, in the total sample (in %)




***Figure 10.03B*** Percentage of children with different wake-up times during weekday and weekend nights, in the total sample (in %)

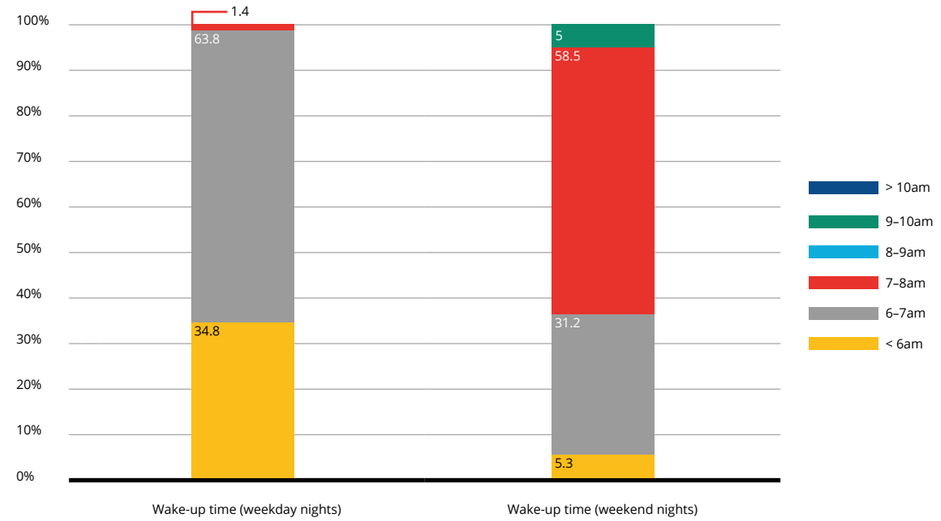


***Figure 10.03C*** Percentage of children with different bed times during weekdays, separately for children attending different grades

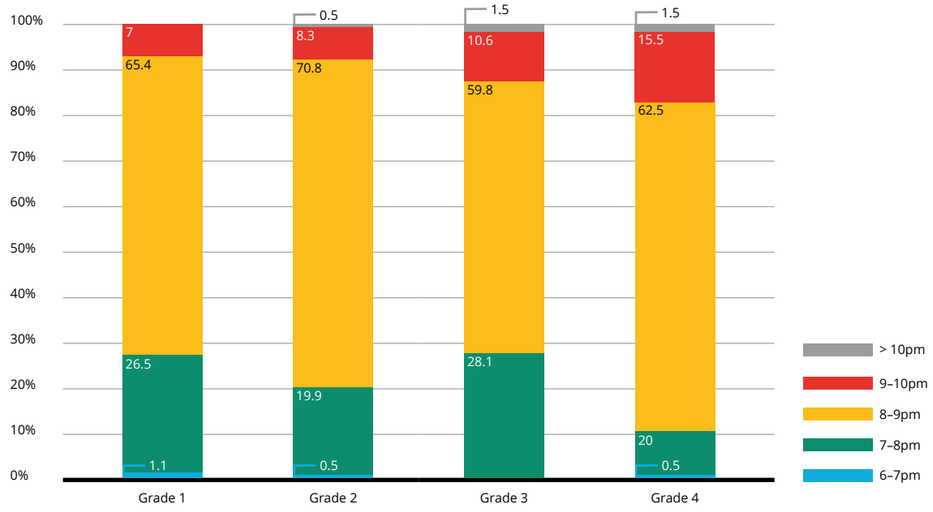



***Figure 10.03D*** Percentage of children with different wake-up times during weekdays, separately for children attending different grades

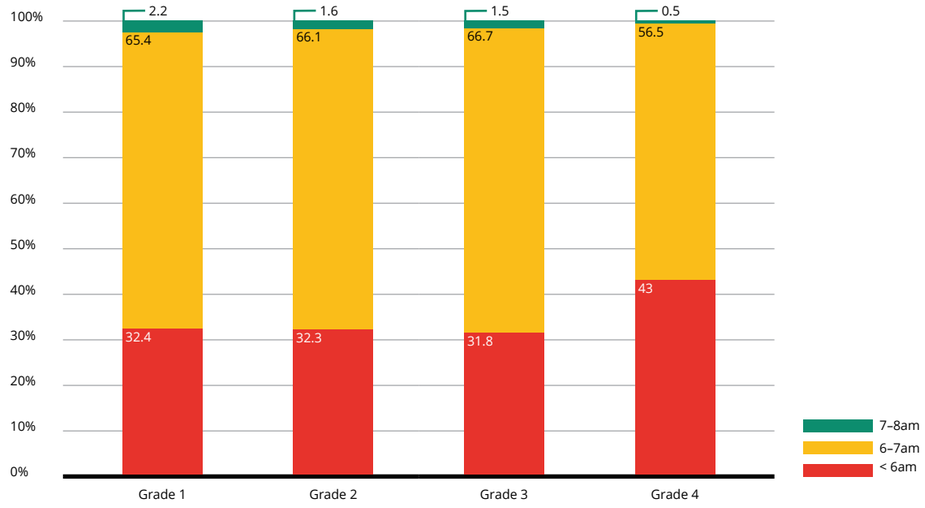
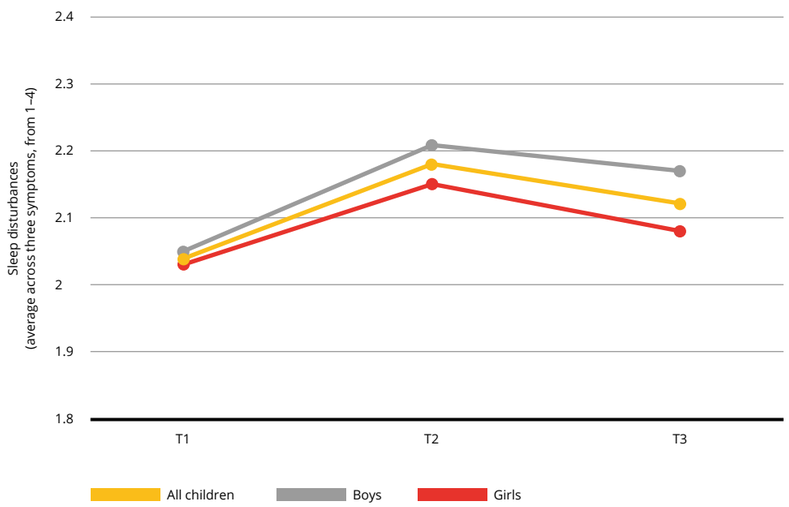





***Figure 10.04*** Development of sleep complaints across the study period, for the total sample and separately for boys and girls




## *Conclusion*

Based on their bed and wake-up times, most children seemed to get enough sleep (between 9–12 hours per night) in purely quantitative terms. This applies equally to girls and boys. Nevertheless, a considerable number of children complained about recurring sleep problems. Sleep changed slightly with age, in the sense that older students tended to go to bed a little later during both weekday and weekend nights.

# *Academic performance and school perceptions*

## *Background*

Children's academic performance is influenced by a multitude of factors including socioeconomic status, health and nutritional status, family environment, social competence, cognitive skills and the ability to pay attention (Banerjee, 2016; Basch, 2011; Stevens & Bavelier, 2012). In socioeconomically deprived environments, essential services such as health care, sanitation, physical security, electricity, and high quality academic and physical education are often lacking (Bradley & Corwyn, 2002; Lu et al., 2016). Low socioeconomic status limits the parents' ability to offer a responsive, supportive and safe learning environment, and to enable access to cognitively stimulating materials such as books and toys (Ferguson et al., 2001; Riley et al., 2014). Poorer families often need to invest most of their resources into covering their household members' basic needs such as food and housing. Therefore, possibilities to invest in the future of their children is limited (Bradley & Corwyn, 2002; Linberg et al., 2019). Children from poorer families are also at increased risk for malnutrition (Voster, 2007), which can manifest in stunted growth. Stunting, in turn, has been associated with poor cognitive function and academic performance (Abebe et al., 2017). By contrast, prior investigations highlighted that physical activity has the potential to elicit both short- and long-term benefits with regard to children's executive function, attention and other academic outcomes (Han, 2018; Ludyga et al., 2020; Xue et al., 2019).

***Poorer families often need to invest most of their resources into covering their household members' basic needs such as food and housing. Therefore, possibilities to invest in the future of their children is limited.***

## *How did we measure school performance and school perceptions?*

To measure academic performance, we collected the end-of-the-year results in Swahili, Mathematics, English (for grade 2 to 4 only), Science (for grade 2 to 4 only), civic studies (for grades 3 and 4 only), and social studies (for grade 3 and 4 only) from each of the participating schools. We used the average of Swahili and Mathematics to estimate a child's overall academic achievement. The Tanzanian school system uses a five-point grading scale from 1 to 5, with higher scores reflecting better academic achievement (5=excellent: 75–100%, 4=very good: 65–74%, 3=good: 45–64%, 2=satisfactory: 30–44% and 1=fail: 0-29%). In addition, to measure satisfaction with school, perceived school-related pressure, and perceived academic competence compared to peers, we applied three items from the Health Behaviour of School-Aged Children (HBSC) survey. To measure school satisfaction, we asked the learners to respond to the question of how they feel about school at present. Possible answers were: I like it, or I don't like it. To assess school-related pressure, we asked the learners how pressured they feel by the schoolwork they must pursue. Possible answers were as follows: 1=not at all, 2=a little bit, 3=some, and 4=a lot. Finally, we asked learners what – in their opinion – their class teacher(s) think about their school performance compared to classmates. Possible answers were: 4=very good, 3=good, 2=similar/same as most classmates, and 1=worse than others.

Children in class

***The Tanzanian school system uses a five-point grading scale from 1 to 5.***



***Figure 11.01*** Academic performances across different school subjects, in the total sample (in %)

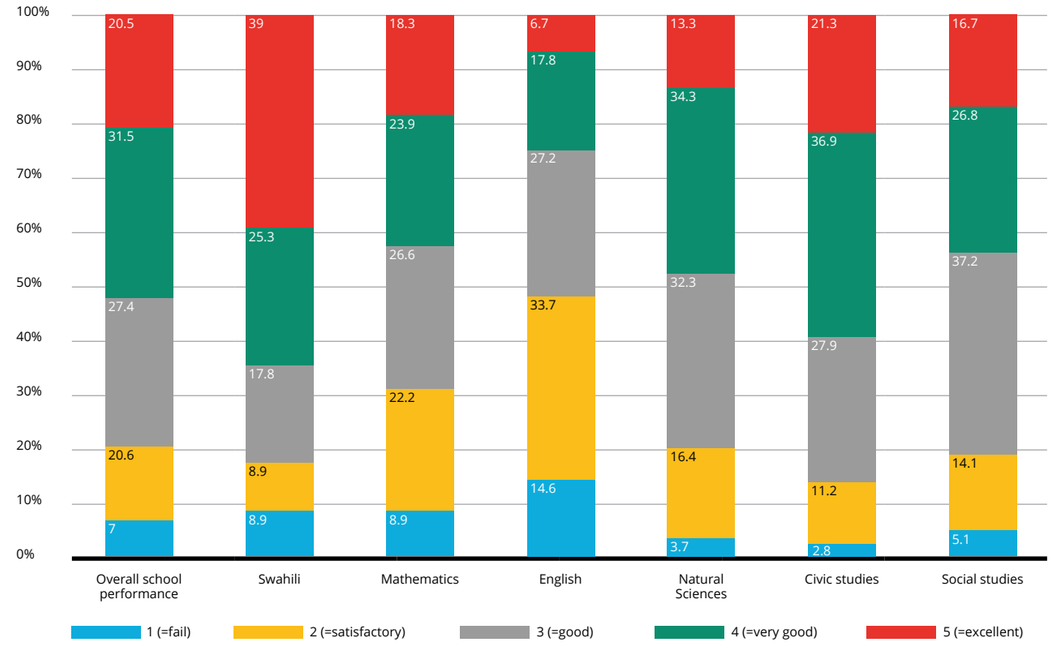



***Table 11.01*** School performance and perceptions, separately for boys and girls and learners attending different grades

| | *Total sample* | | *Boys* | | *Girls* | | *Grade 1* | | *Grade 2* | | *Grade 3* | | *Grade 4* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| ***Overall school performance*** | 58.28 | 23.41 | 55.43 | 23.82 | 60.81 | 22.76 | 60.13 | 28.55 | 64.00 | 26.05 | 54.23 | 21.14 | 57.13 | 17.28 |
| ***Swahili*** | 64.28 | 27.82 | 60.07 | 28.44 | 68.00 | 26.75 | 65.26 | 34.83 | 65.52 | 31.40 | 62.38 | 24.73 | 64.78 | 20.80 |
| ***Mathematics*** | 52.12 | 25.05 | 50.80 | 25.38 | 52.28 | 24.72 | 54.38 | 27.95 | 62.49 | 24.37 | 45.99 | 23.35 | 49.48 | 22.14 |
| ***English (only grade 2, 3 and 4)*** | 41.67 | 22.32 | 28.30 | 21.77 | 44.75 | 22.41 | na | na | 58.65 | 26.87 | 43.73 | 23.93 | 37.56 | 18.49 |
| ***Natural science (only grade 2, 3 and 4)*** | 55.26 | 19.78 | 53.88 | 19.80 | 56.50 | 19.71 | na | na | 64.15 | 15.20 | 57.13 | 21.42 | 52.01 | 17.45 |
| ***Civic studies (only grade 3 and 4)*** | 61.00 | 20.74 | 59.08 | 21.95 | 62.76 | 19.44 | na | na | na | na | 56.65 | 20.12 | 66.33 | 20.28 |
| ***Social studies (only grade 3 and 4)*** | 55.79 | 21.23 | 56.51 | 22.16 | 55.14 | 20.36 | na | na | na | na | 59.15 | 22.94 | 51.69 | 18.15 |
| ***Pressure (1–4)*** | 3.08 | 0.77 | 3.07 | 0.78 | 3.09 | 0.76 | 2.97 | 0.70 | 3.11 | 0.75 | 3.07 | 0.83 | 3.16 | 0.77 |
| ***Performance compared to others (1–4)*** | 2.54 | 0.68 | 2.58 | 0.68 | 2.51 | 0.68 | 2.56 | 0.60 | 2.43 | 0.68 | 2.55 | 0.71 | 2.61 | 0.71 |

Note: na = not applicable.

## *Results*

End-of-the-year results were available for 949 learners, whereas 916 children answered questions about school satisfaction, pressure and perceived academic competence. As shown in Figure 11.01, only 2.8% (civil studies) to 14.6% (English) failed to meet the expected requirements. With regard to overall school performance, 20.5% of the children received the highest grade (excellent).

As shown in Table 11.01, girls had statistically significantly higher school grades than boys in overall school performance, Swahili, English, civic studies, and social studies. No differences were found with regard to mathematics, natural science and social studies. Overall academic performance was higher in learners from grade 1 and grade 2, compared to peers from grade 3 and grade 4. Whereas no grade-based differences were found for Swahili, performances in mathematics were higher in grade 1 and 2 learners compared to children from more advanced grades. Similarly, performances in English language, natural sciences, and social studies were statistically significantly higher among learners from lower grades. By contrast, grade 4 students achieved better performances in civic studies compared to peers attending grade 3.

816 learners had valid end-of-the-year results at T1 and T3. With regard to changes from baseline to follow-up, the overall school grades of the students (end-of-the-year results) slightly decreased from M=58.96 to M=44.88). A similar pattern was observed for boys and girls (Figure 11.02).

Figure 11.03 reveals that the majority of the learners (99.0%) liked school. No significant differences existed between boys and girls and learners from lower or higher grades. However, a substantial percentage of learners perceived pressure at school, with 41.7% reporting 'some pressure' and 33.2% 'a lot of pressure' (Figure 11.04). Perceived school pressure

***Figure 11.02*** Development of end-of-the-year results across the study period, for the total sample and separately for boys and girls

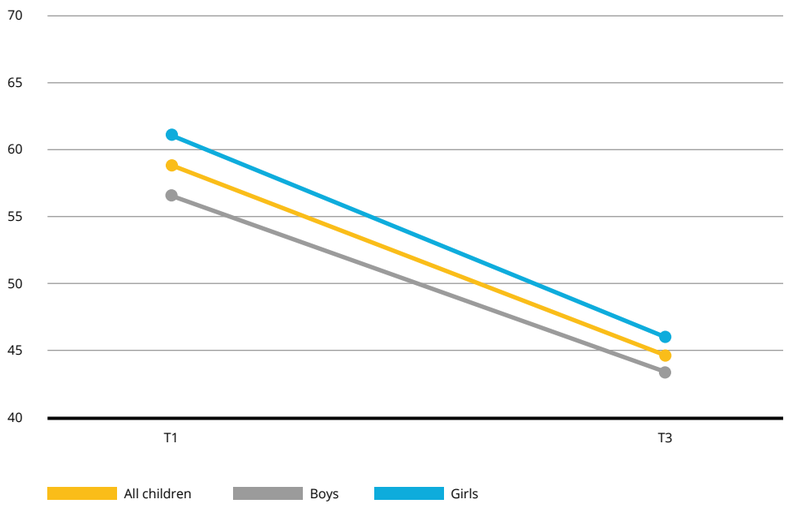
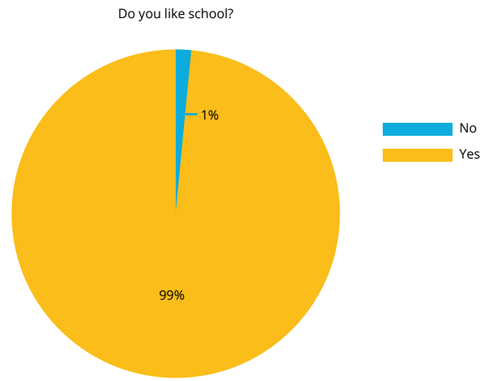





***Figure 11.03*** School satisfaction, for the total sample




was similar in boys and girls and learners from different grades. Despite this, the learners rated their school performances quite positively with more than half rating themselves as good (44.7%) or very good (6.8%) (no differences found between boys and girls) (Figure 11.04). Only 4.1% of the students felt that they were underachieving in comparison to their peers. Perception of underachievement was particularly high among students in the second grade.

Overall, 738 children answered the questions with regard to school pressure and self-perception of academic achievement three times and had valid school perception data across all measurement time points. As shown in Figure 11.05, the level of perceived school pressure increased from T1 to T3, with the increment being similar among boys and girls. The learners' ratings regarding their own academic performance became more positive from T1 (M=2.54) to T2 (M=2.80), whereas a significant decrease was observed from T2 to T3 (M=2.61).

***Figure 11.04*** Perceived school pressure and perceived school performance compared to others, for the total sample

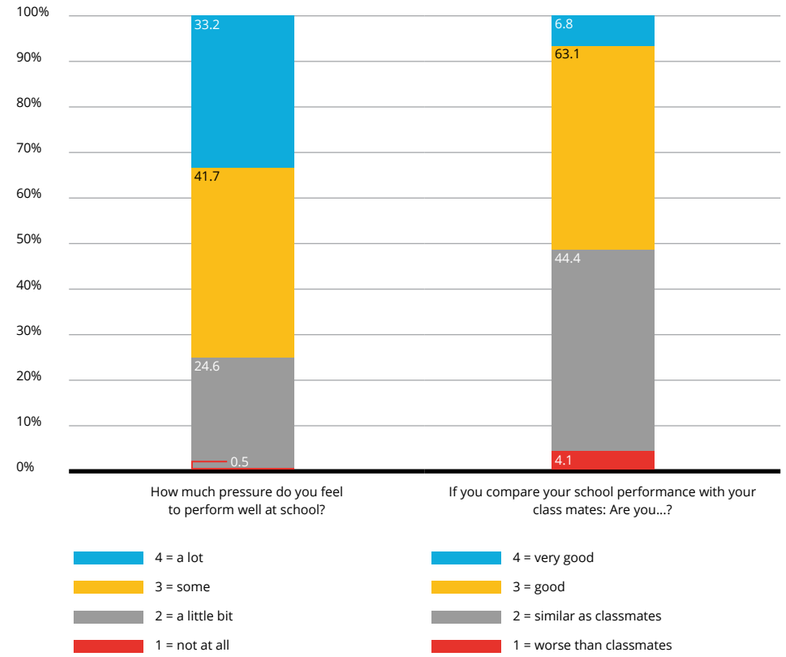


***Figure 11.05*** Development of perceived pressure at school across the study period, for the total sample and separately for boys and girls

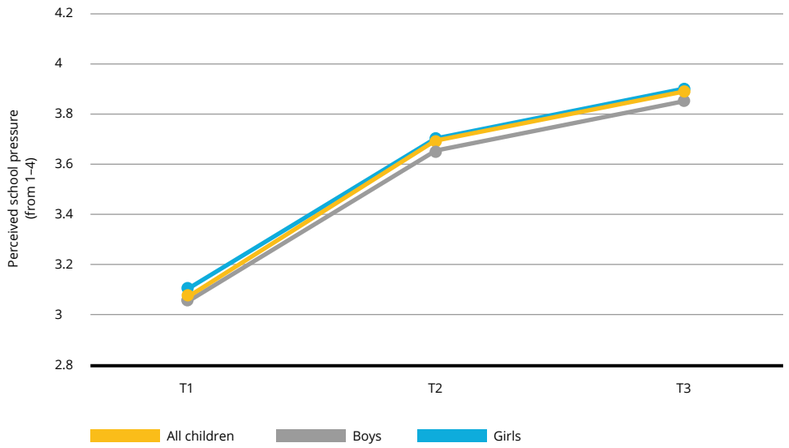
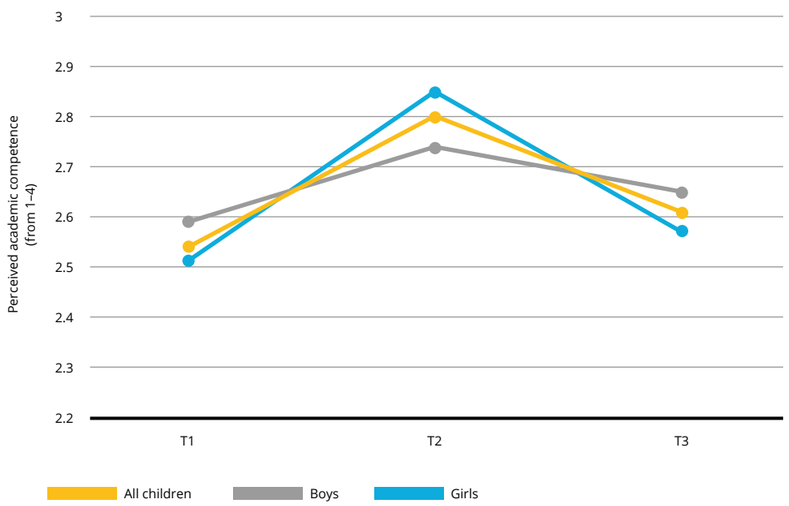



***Figure 11.06*** Development of perceived academic performance across the study period, for the total sample and separately for boys and girls






▲ Children participating in the flanker task

**Flanker task note**

In the present study, we also used computerized tests to assess children's selective attention and inhibitory control via the Flanker tasks. The results of these tests are not included in this report and will be reported in specialized scientific journals.

▲ Children completing the computerized task to assess inhibitory control

## *Conclusion*

Overall, it can be stated that children's school performance was satisfactory overall. Only few children seemed unable to keep up in the first four grades. Girls seemed to have an advantage over boys when it comes to several school subjects (particularly languages and civic/social studies). Despite this, boys did not perceive more pressure at school than girls. In terms of school enjoyment, most of the children liked going to school. Perceived academic competence was on a medium level and reached a peak after the second data assessment. Perceived school pressure increased markedly from T1 to T3.

***Overall, it can be stated that children's school performance was satisfactory.***

# *Physical activity and physical fitness*

## *Background*

Due to the concerning rise in sedentary behaviour together with non-communicable diseases, the World Health Organization (WHO) published a Global Action Plan in 2018, which recommended physical activity promotion already at an early age (WHO, 2018). Children also become considerably less physically active as they go through primary school (Jago et al., 2020), making this a particular relevant target population for health programs. Worldwide, a considerable shift in lifestyle factors is responsible for the fact that 81% of 11-17 year olds lack sufficient physical activity (WHO, 2018). A previous meta-analysis confirmed the important role of physical activity on various aspects of cognitive functioning in children, with the largest gains observed with longer interventions (22 weeks) and session duration of PA (30-60min) (Ludyga et al., 2020). However, most of the current evidence stems from paediatric populations in high-income countries. School-based physical activity interventions in Sub-Saharan Africa show promising, yet inconsistent results (Gall et al., 2018; García-Hermoso et al., 2020; Takehara et al., 2021).

***Children also become considerably less physically active as they go through primary school, making this a particular relevent target population for health programs.***

### *How did we measure physical activity and fitness?*

We applied two self-report instruments to collect information on children's self-reported physical activity (Bauman et al., 2010; Biddle et al., 2011). The first instrument was a single-item tool taken from the HBSC survey. The exact wording of this item was as follows: 'Physical activity is any activity that increases your heart rate and makes you get out of breath some of the time. Over the past 7 days, on how many days did you engage in such activity?' Children could answer the question on a scale from 1 to 7 days (Aït-Khaled et al., 2009). The second instrument was the Physical Activity Questionnaire for Children (PAQ-C), a 9-item instrument specifically designed for school-aged children (Crocker et al., 1997). Due to the limited age of our sample and time constraints, we decided to use only six items. The PAQ-C is a 7-day recall focussing on several domains. Responses are given on a 5-point Likert-scale (from 1 to 5). Items included in the present study refer to physical activity accumulated during school sporting events/ physical education, recess, at lunch, after school, in the evening and on weekends. Previous research has shown that the PAQ-C has acceptable reliability and convergent validity (Bervoets et al., 2014; Kowalski et al., 1997; Wang et al., 2016). To assess physical activity "objectively", we used hip-worn accelerometer devices (Actigraph wGT3x-BT; Shalimar, FL, USA). Children wore the device for 7 consecutive days to assess a full week, with a sampling epoch of 15 s (Rowlands, 2007). Time per day spent in moderate physical activity (MPA; ≥3 metabolic equivalents of task (MET)) and vigorous physical activity (VPA; ≥6 MET) were determined based on the raw accelerometry counts and the ActiLife® computer software (Actigraph; Shalimar, FL, USA), with cut-off values derived from Freedson et al. (1998). ActiGraph accelerometers have been validated for children (Crouter et al., 2013; Hänggi et al., 2013). To measure children's cardiorespiratory fitness, we used the 20-m shuttle run test (Leger et al., 1988). All children were instructed to report any body discomfort before the start of test to avoid that students who felt unwell or uncomfortable participated in the test. Once children were familiar with the test procedures, they were asked to run back and forth on the 20-m flat course (marked with colour-coded cones) in groups of 10–15 children, following

***Children also become considerably less physically active as they go through primary school.***

Children participating in the shuttle run test



Child wearing an actigraph device around the hip

Preparation of physical activity trackers (Actigraph wGT3X-BT) for drop-off at schools

the pace of a pre-recorded sound signal. The test started with a running speed of 8.5 km/h; we then increased the frequency of the signal every minute by 0.5 km/h. The test ended when a child failed to follow the pace in two consecutive intervals. VO2max estimates were calculated based on the age of the participating child and the speed at which the child stopped running. To assess upper body strength, we used the grip strength test (Saehan hydraulic hand dynamometer, MSD Europe BVBA; Tisselt, Belgium). We measured the hand span (distance from the tip of the thumb to the tip of the little finger) of the child's dominant hand (to the nearest 0.5 cm) before the start of the test. This allowed us to adjust the grip span on the dynamometer (Espana-Romero et al., 2008; Ruiz et al., 2008). The child gripped the dynamometer with the arm fully extended in an upright seating position. During this time, no other parts of the body touched the dynamometer, and the arm being tested was not squeezed against the body. Each child had six trials in total (three per hand), with a 30-s rest between trials, alternating between hands. Scores were noted to the nearest 1 kg.

## *Results*

Data on self-reported physical activity were available for 916 children at baseline. While all of the children reported that they would engage in school sporting events/physical education, more than 40 percent of the children (43.7%) reported that such events were rare and that they would hardly ever engage (Figure 12.01A). As shown in Figure 12.01B, many children were physically active during recess/breaks and lunch time. More than half of the students (52.0%) ran and played at least a little bit during recess, whereas 33.6% reported to do so during lunch time. With regard to leisure time physical activity (Figure 12.01C), 21.6% and 6.4% of the children reported that they do not engage in sports, dance or other (physically active) playful games during weekdays and weekend days, respectively, whereas approximately 30 percent of the students reported that they would participate in such activities almost every day (weekdays: 27.8%, weekend days: 28.5%).

Overall, more than two thirds of the children engaged in sports, dance and other playful games at least two times per week (both during weekdays and weekend days). A similar (or even more) positive picture emerged when parents described the physical activity behaviour of their offspring (Figure 12.02). According to the parents' opinion, almost eight of ten children (77.7%) of the children engaged in at least 60 minutes of physical activity per day on every day of the week, whereas only a small percentage of parents felt that their child would engage in physical activity no day (8.7%) or only on a few days per week.

As shown in Table 12.01, participation in physical education was similar in boys and girls. In contrast, boys were statistically significantly more active during recess/break time, and after school. Boys also had a higher PAQC mean score than girls. Interestingly, this did not correspond with parents' and guardians'

***Figure 12.01A*** Child-reported physical activity levels during physical education classes, in the total sample (in %)

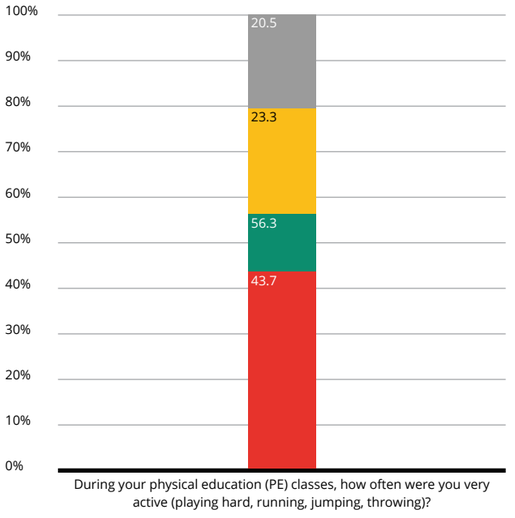





***Figure 12.01B*** Child-reported physical activity levels during recess and lunch time, in the total sample (in %)

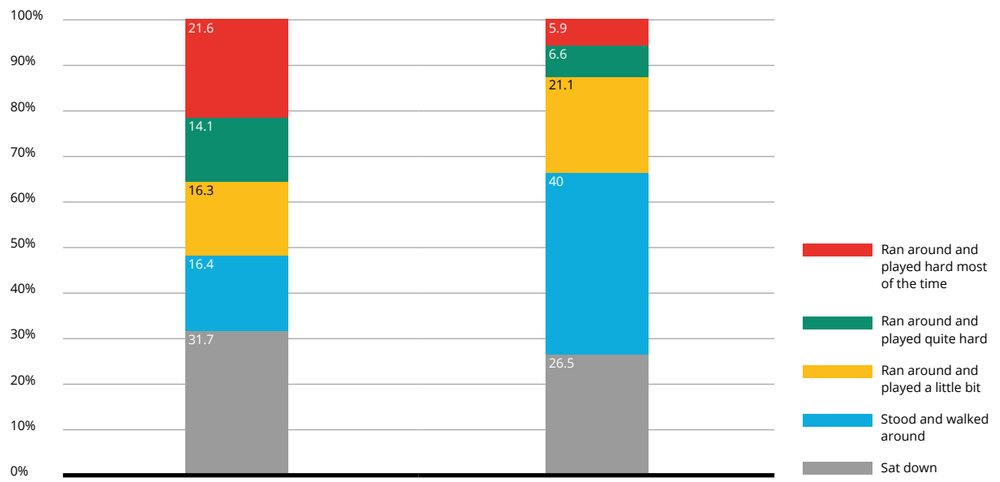



***Figure 12.01C*** Child-reported physical activity levels during leisure time, in the total sample (in %)

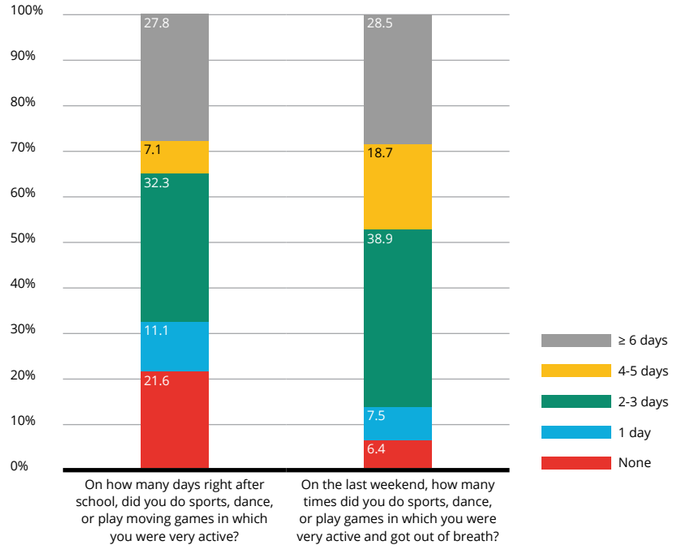



***Table 12.01*** Child-reported physical activity levels, separately for boys and girls and children attending different grades

| | Total sample | | Boys | | Girls | | Grade 1 | | Grade 2 | | Grade 3 | | Grade 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| ***Child-reported physical activity*** | | | | | | | | | | | | | | |
| ***During physical education*** | 3.21 | 1.20 | 3.20 | 1.20 | 3.22 | 1.21 | 3.03 | 1.13 | 3.11 | 1.15 | 3.34 | 1.26 | 3.29 | 1.21 |
| ***During recess/break time*** | 2.77 | 1.54 | 2.94 | 1.52 | 2.61 | 1.55 | 2.88 | 1.46 | 2.88 | 1.40 | 2.87 | 1.59 | 2.49 | 1.66 |
| ***During lunch time*** | 2.25 | 1.10 | 2.29 | 1.11 | 2.22 | 1.09 | 2.15 | 0.63 | 2.11 | 0.70 | 2.35 | 1.35 | 2.35 | 1.33 |
| ***Right after school*** | 3.08 | 1.47 | 3.06 | 1.45 | 3.10 | 1.49 | 3.13 | 1.46 | 2.97 | 1.47 | 3.00 | 1.44 | 3.24 | 1.50 |
| ***On the last weekend*** | 3.55 | 1.17 | 3.62 | 1.18 | 3.49 | 1.15 | 3.57 | 1.11 | 3.65 | 1.12 | 3.60 | 1.16 | 3.40 | 1.24 |
| ***PAQC mean score*** | 3.05 | 0.68 | 3.11 | 0.67 | 2.99 | 0.69 | 3.04 | 0.59 | 3.04 | 0.67 | 3.10 | 0.72 | 3.01 | 0.73 |

perspective who believed that boys and girls were similarly active. With regard to grade level, the self-reported physical activity level during sporting events/physical education lessons and during lunch time was higher among grader 3 and grade 4 learners compared to students from lower grades. With regard to physical activity during recess, the activity levels of grade 4 students were statistically significantly lower compared to younger learners. With regard to after-school and weekend-based physical activities, no significant differences were found between learners from different school grades. Similar, no differences were found between students from different grades based on the reports of the children's parents/guardians.

Valid baseline actigraphy data was available for 845 children. As shown in Figure 12.03, nine of ten children accumulated sufficient amounts of physical activity and thus met international physical activity guidelines (92.9%). Although this percentage was higher among boys compared to girls, the difference was not statistically significant. As shown in Table 12.02, boys accumulated 111.02 min of MVPA per day, whereas girls engaged only for 89.66 min per day in at least moderately intensive physical activity. Regarding the different grades, learners in grade 3 accumulated more daily MVPA than learners from the other grades. Table 12.02 also highlights that children accumulated relatively high amounts of sedentary activity, with an average of 578.69 min per day. Sedentary time was not statistically significantly higher in girls (582.82 min) and boys (574.20 min). Nevertheless, time spent in sedentary activities gradually increased from grade 1 (552.38 min) to grade 4 (610.73 min).

Additionally, 543 children had valid actigraphy data across all measurement timepoints. Figure 12.04A reveals that in the total sample, physical activity levels increased from T1 to T2, and then dropped below the initial level at T3. The overall pattern was similar in girls and boys. For sedentary activities, the levels were relatively stable across time. From T1 to T3, sedentary time increased by approximately 5 min per day in the total sample (Figure 12.04B). Again, a similar pattern was observed in boys and girls.

Descriptive data on children's physical fitness is shown in Table 12.02. 870 children completed the 20m Shuttle run test, whereas grip strength was assessed in 912 children. Average number of laps completed in the 20m Shuttle run test was 41.51 laps. Average VO2max was 55.77, average grip strength 12.31 kg. Significant sex differences were found in all of the three variables. Thus, boys completed statistically significantly more laps in the Shuttle run test, had higher estimated VO2max, and achieved higher grip strength. Whereas children from higher grades run more laps in the 20m Shuttle run test, estimated VO2max was lower among learners from higher grades. In contrast, a gradual increase was observed in grip strength from grade 1 to grade 4.

***Figure 12.02*** Number of days with moderate-to-vigorous physical activity levels of ≥60min/day, according to parents in the total sample and separately for boys and girls (in %)

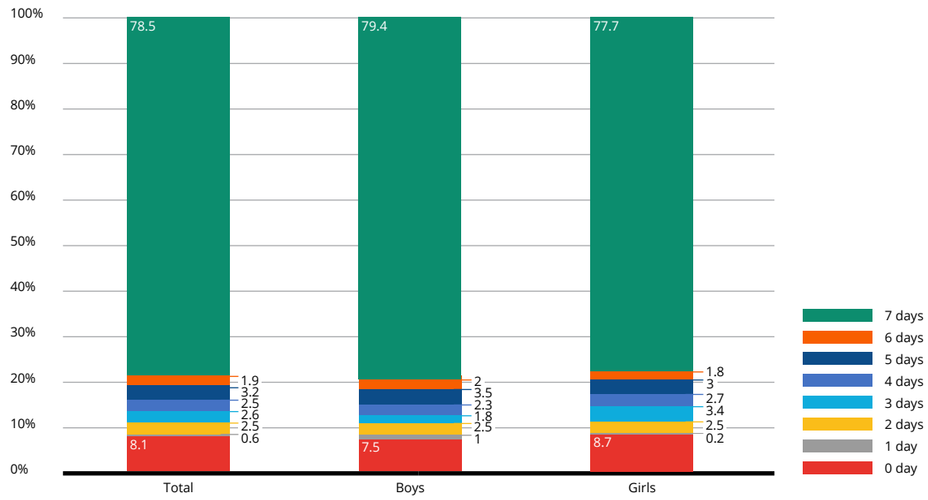



***Figure 12.03*** Meeting physical activity recommendations (≥60min/day) of moderate-to-vigorous physical activity, based on accelerometer data, for the total sample and separately for boys and girls (in %)

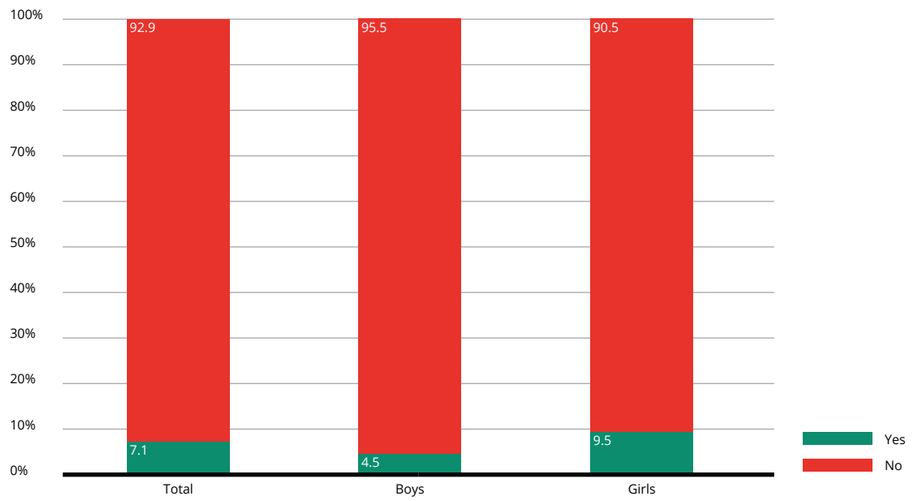


***Table 12.02*** Accelerometer-based physical activity and physical fitness, separately for boys and girls and learners attending different grades

| | *Total sample* | | *Boys* | | *Girls* | | *Grade 1* | | *Grade 2* | | *Grade 3* | | *Grade 4* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| ***Accelerometer-based data (Total)*** | | | | | | | | | | | | | | |
| ***Sedentary behavior*** | 578.69 | 65.04 | 574.20 | 67.51 | 582.82 | 63.40 | 552.38 | 64.34 | 566.39 | 62.20 | 579.16 | 63.66 | 610.73 | 58.26 |
| ***Moderate physical activity*** | 67.15 | 17.42 | 73.52 | 18.07 | 61.30 | 14.54 | 66.95 | 15.67 | 67.28 | 16.87 | 69.79 | 18.53 | 63.96 | 17.41 |
| ***Vigorous physical activity*** | 32.73 | 15.43 | 37.50 | 17.61 | 28.36 | 11.52 | 30.76 | 13.71 | 32.38 | 14.08 | 35.87 | 17.91 | 30.71 | 13.90 |
| ***MVPA**** | 99.89 | 30.60 | 111.02 | 32.84 | 89.66 | 24.25 | 97.71 | 27.47 | 99.66 | 28.85 | 105.66 | 33.73 | 94.67 | 29.31 |
| ***Accelerometer-based data (Weekdays)*** | | | | | | | | | | | | | | |
| ***Sedentary behavior*** | 584.60 | 68.76 | 579.86 | 71.79 | 588.95 | 65.63 | 556.00 | 66.76 | 570.03 | 67.02 | 585.19 | 66.49 | 620.36 | 58.66 |
| ***Moderate physical activity*** | 65.43 | 17.77 | 71.57 | 18.32 | 59.80 | 15.23 | 64.22 | 16.54 | 65.59 | 17.79 | 68.32 | 18.66 | 62.71 | 17.17 |
| ***Vigorous physical activity*** | 31.62 | 16.05 | 36.41 | 18.33 | 27.23 | 12.08 | 28.93 | 13.29 | 30.88 | 13.95 | 35.17 | 19.46 | 30.02 | 14.32 |
| ***MVPA**** | 97.05 | 31.31 | 107.98 | 33.45 | 87.02 | 25.38 | 93.16 | 27.87 | 96.47 | 29.55 | 103.49 | 35.14 | 92.74 | 29.11 |
| ***Accelerometer-based data (Weekend)*** | | | | | | | | | | | | | | |
| ***Sedentary behavior*** | 564.54 | 83.96 | 561.97 | 84.23 | 566.88 | 83.74 | 544.67 | 78.27 | 558.10 | 79.34 | 565.91 | 82.72 | 584.48 | 89.58 |
| ***Moderate physical activity*** | 71.83 | 21.93 | 79.01 | 23.94 | 65.30 | 17.57 | 74.51 | 17.68 | 71.88 | 20.34 | 73.91 | 23.13 | 67.13 | 24.07 |
| ***Vigorous physical activity*** | 35.68 | 19.12 | 40.52 | 21.68 | 31.28 | 15.18 | 35.78 | 18.15 | 36.33 | 19.58 | 37.77 | 20.44 | 32.41 | 17.35 |
| ***MVPA**** | | | | | | | | | | | | | | |
| ***Physical fitness*** | | | | | | | | | | | | | | |
| ***Number of laps completed*** | 41.51 | 18.19 | 48.80 | 18.77 | 34.46 | 14.54 | 34.52 | 13.00 | 36.81 | 15.69 | 44.18 | 18.44 | 48.37 | 20.47 |
| ***Estimated VO2max*** | 55.77 | 26.26 | 57.59 | 27.07 | 54.02 | 25.36 | 57.75 | 28.34 | 55.18 | 24.04 | 56.65 | 30.27 | 55.65 | 27.46 |
| ***Grip strength*** | 12.31 | 4.37 | 13.37 | 4.35 | 11.34 | 4.17 | 8.24 | 2.85 | 10.60 | 3.25 | 13.52 | 3.20 | 15.95 | 3.76 |

*MVPA – Moderate-to-vigorous physical activity

***Figure 12.04A*** Moderate-to-vigorous physical activity

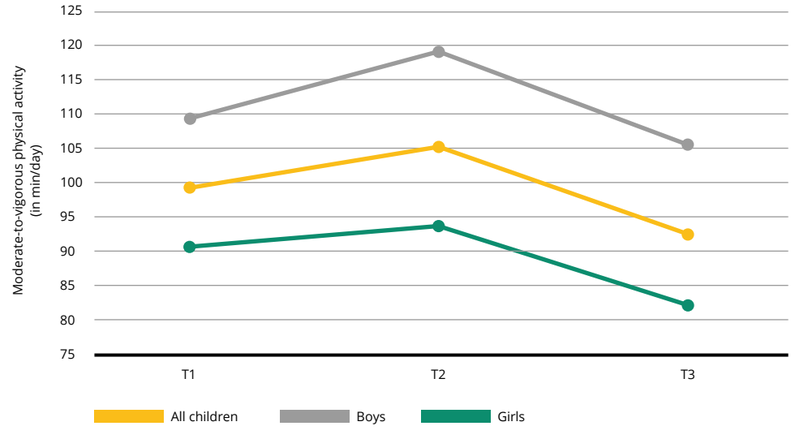
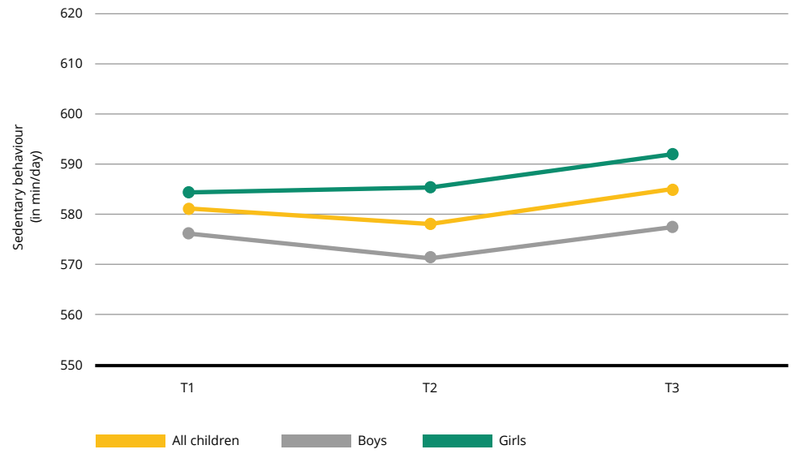



***Figure 12.04B*** Development of sedentary behaviour across the study period, for the total sample and separately for boys and girls




***Boys accumulated significantly more moderate-to-vigorous physical activity per day than girls.***

***Figure 12.05A*** Development of laps completed in the 20m Shuttle run test, across the study period, for the total sample and separately for boys and girls

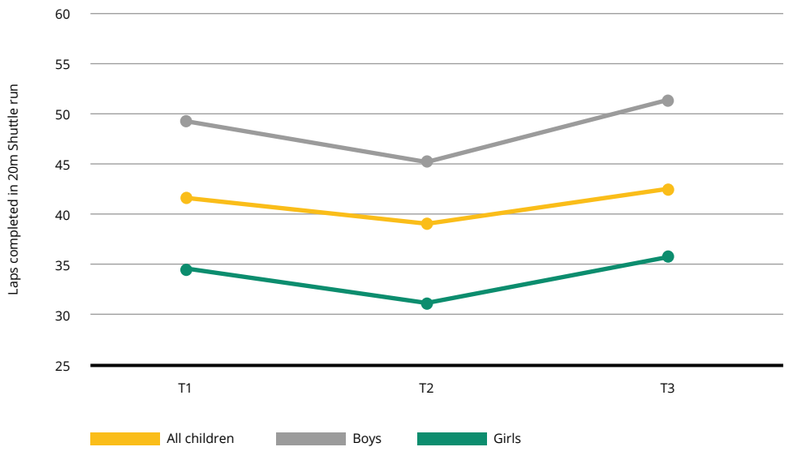



***Figure 12.05B*** Development of estimated VO2max across the study period, for the total sample and separately for boys and girls

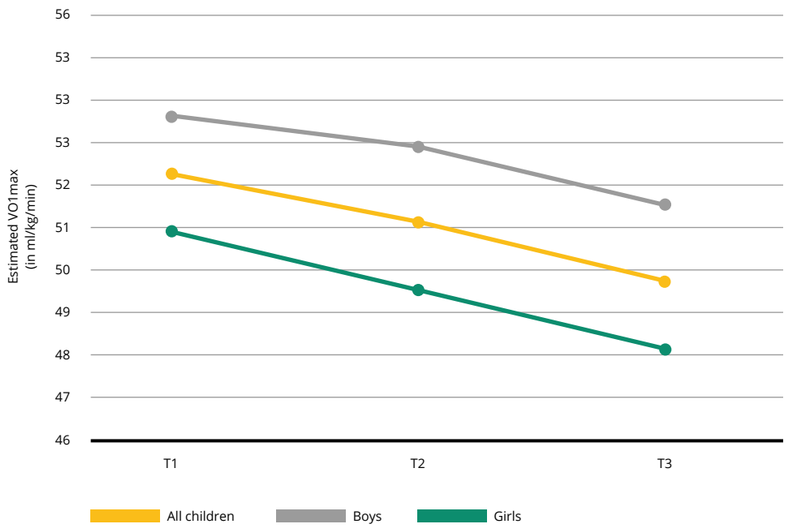
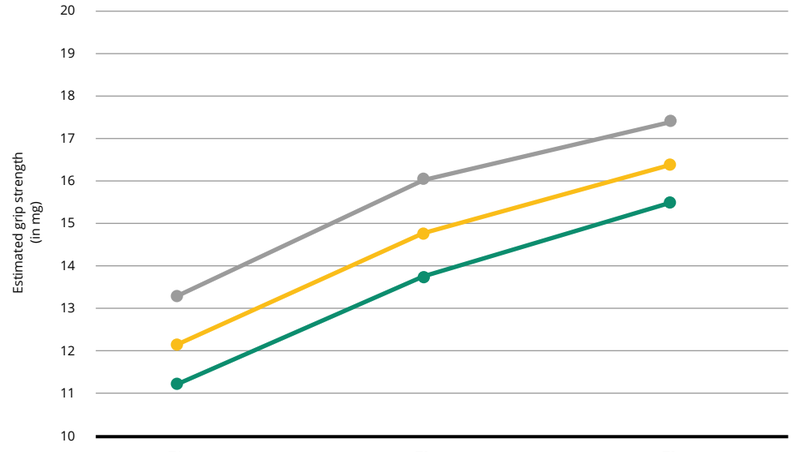





***Figure 12.05C*** Development of grip strength across the study period, for the total sample and separately for boys and girls




In total, 742 of the children completed the 20m Shuttle run test three times. As shown in Figure 12.05A, the performance in the 20m Shuttle run test decreased from T1 to T2, and then increased again from T2 to T3. This pattern did not differ between boys and girls. With regard to estimated VO2max, a steady decrease was observed from T1 and T3 (Figure 12.05B). Across all measurement timepoints, boys achieved higher estimated VO2max scores than girls. With regard to grip strength, 747 children had valid scores across all measurement time points. As shown in Figure 12.05C, the scores increased from T1 to T3, with similar increases found in boys and girls.

## Conclusion

Overall, children of the present sample were very active with more than 90% of the participants meeting international physical activity recommendations. Boys accumulated more MVPA per day than girls. However, most of the girls also achieved recommended international physical activity standards. According to the parents/guardians, almost 80% of the children engaged in at least 20 minutes of physical activity per day on every day of the week. Moreover, more than two thirds of the children engaged in sports, dance and other playfurl games at least two times per week (both during weekdays and weekend days). Time spent in sedentary activities gradually increased from grade 1 to grade 4. Finally, four out of ten learners reported very low levels of physical activity during school sporting events or physical education classes. With regard to their cardiorespiratory fitness levels, the performances of the present sample were comparable to those of previous child studies in Tanzania (Lang et al., 2018). With more than 40 laps completed, the performances were close to the performances of children in the highest centile ranks observed in a 50-country comparative study.

**742**

***children completed the 20m Shuttle run test three times.***

# *Dietary behaviour and nutritional status*

## *Background*

Poor nutrition and infectious diseases can affect children's health and educational success (Hurlimann et al., 2017; Rytter et al., 2014). Over the past years, many Sub-Saharan African populations have been facing a lifestyle transition from a traditional to a more westernized lifestyle (Thathiah et al., 2013; Vorster et al., 2011), including dietary consumption patterns and nutrient intake. The transition towards a high-caloric and fat diet with poor nutritional value, however, is linked to a range of long-term consequences for child nourishment. At the moment, many countries in Sub-Saharan Africa are facing a double burden of under- and overnutrition. Undernourishment can be both a cause and a consequence of poverty (Local Burden of Disease Educational Attainment, 2020; UNICEF, 2019). Insufficient nutrient and energy intake have been shown to impede children's curiosity, interest, and learning capabilities among stunted children (Mohammed Teni, 2017). Previous research has also shown that children from low- and middle-income countries (LMICs) have a specially high risk of food insecurity (Naicker et al., 2015; Shankar et al., 2017), multiple micronutrient deficiencies (Vorster, 2010), malnutrition (including both overnutrition/obesity and undernutrition/stunting), which are all linked to poor academic and cognitive performance (Black et al., 2013; Fiorentino et al., 2018). Nutrition programs, including micronutrient supplementation, may have the potential to enhance or compensate for deficits in cognitive performance (Best et al., 2011; Roberts et al., 2022).

***The transition towards a high-caloric and fat diet with poor nutritional value, however, is linked to a range of long-term consequences for child nourishment.***


## *How did we measure dietary behaviour and nutritional status?*

Information on dietary intake was obtained from the parents/guardians to determine the adequacy of child's intake of macro- and micronutrients. Dietary intake of children was assessed with a culturally sensitive food item checklist for each country (Wentzel-Viljoen et al., 2011; Zack et al., 2018). The checklist was administered to the child's carer at baseline. In addition, USAID (www.usaid.gov) defines food security as a situation in which all people at all times have physical and economic access to sufficient food to meet their dietary needs for a productive and healthy life. For the purpose of this study, we assessed food security with a questionnaire based on the Household Food Insecurity Access Scale (Salvador Castell et al., 2015), which has been validated in industrialized countries and LMICs. For example, the study by Knueppel et al. (2010) showed satisfactory validity and reliability among poor households in rural Tanzania. The micronutrient status of children was assessed using a finger prick technique. Five blood drops were collected on a filter card. We sent these dried blood spot samples to the Neubergglobal Laboratory in Durban, South Africa. The eluted spots were screened for concentrations of retinol binding protein (RBP), a vitamin A marker, vitamin D, zinc, and serum transferring receptor (sTfR), an iron deficiency marker. The following age-specific cut-offs were used to define micronutrient deficiencies:

- Vitamin A deficiency: Values of < 0.7 mol/L were considered as Vitamin A deficient status.
- Vitamin D deficiency: Values of < 25 ng/ml were considered as Vitamin D deficient status.
- Zinc deficiency: For children younger than 10 years, values of < 12.24 mol/L were considered as deficient, whereas values of ≥ 15.29 were considered as high. For children aged 11 years or older, values of < 13.77 were considered as deficient, whereas values of ≥ 18.36 were considered as high.
- Iron deficiency: Values of < 8.3 mg/L are considered as deficient.



***Figure 13.01*** Meals consumed during the day prior to the data assessment, for the total sample

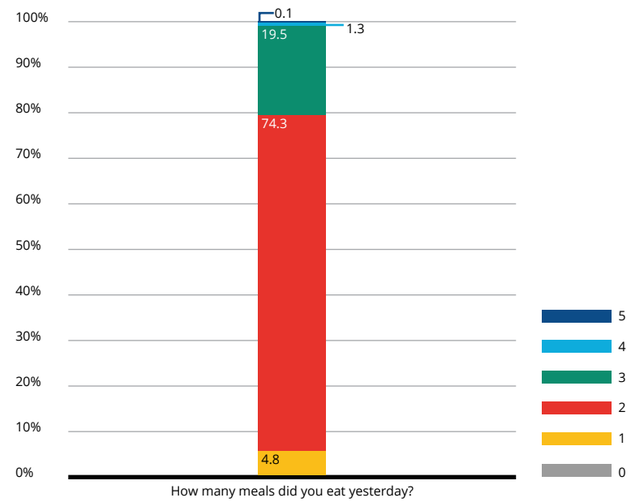



***Figure 13.02*** Food security on household level (parental report), for the total sample

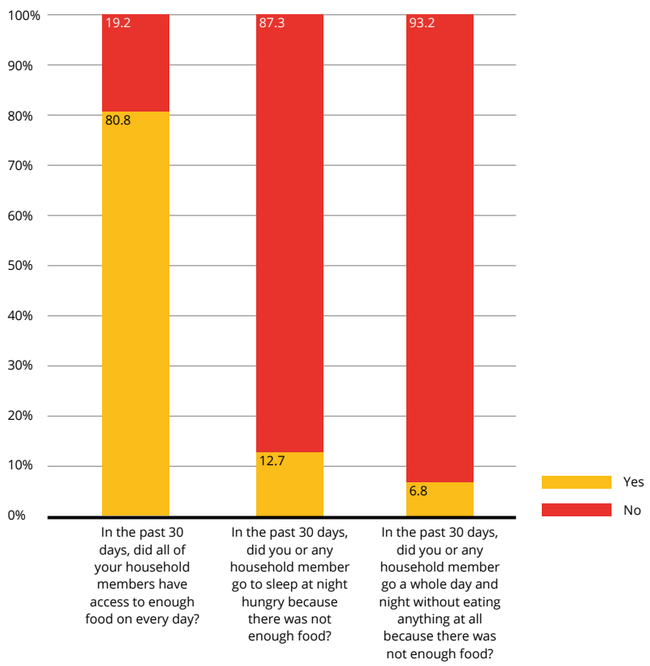


***Table 13.01*** Consumed food groups and number of food items, separately for boys and girls and learners attending different grades

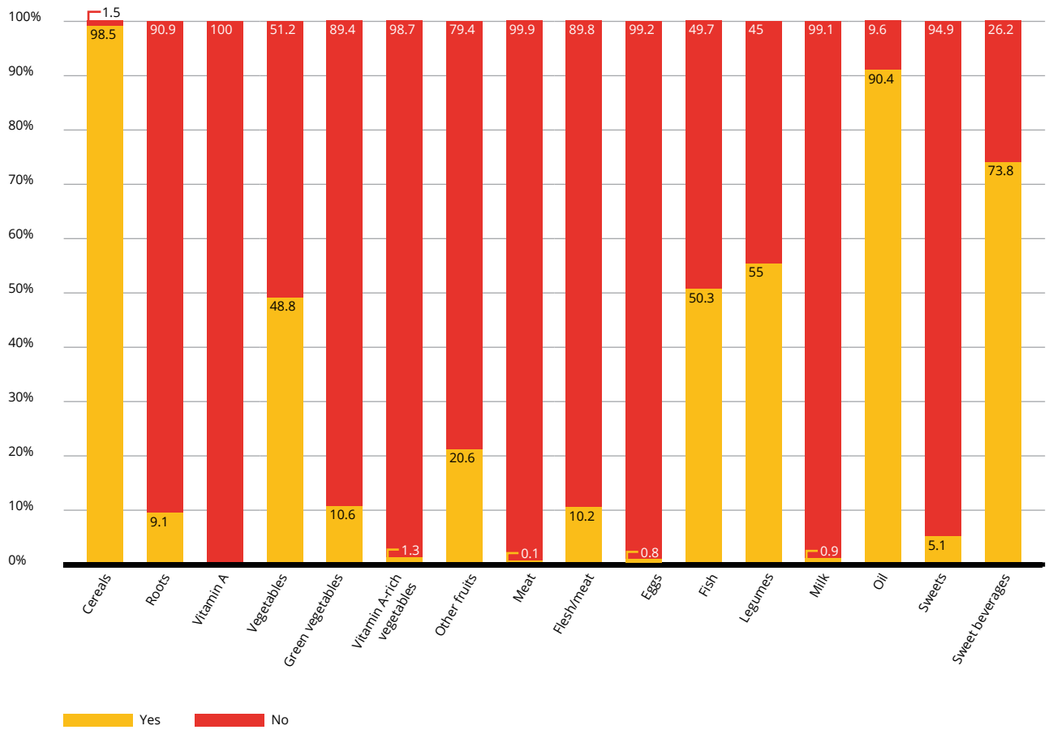
| | Total sample | | Boys | | Girls | | Grade 1 | | Grade 2 | | Grade 3 | | Grade 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| ***Cereals*** | 1.71 | 0.64 | 1.67 | 0.65 | 1.75 | 0.63 | 1.80 | 0.62 | 1.71 | 0.68 | 1.68 | 0.61 | 1.69 | 0.65 |
| ***Roots*** | 0.10 | 0.31 | 0.09 | 0.30 | 0.11 | 0.33 | 0.08 | 0.27 | 0.11 | 0.35 | 0.09 | 0.30 | 0.11 | 0.34 |
| ***Vitamin A*** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ***Vegetables*** | 0.56 | 0.64 | 0.54 | 0.63 | 0.59 | 0.66 | 0.61 | 0.69 | 0.52 | 0.67 | 0.55 | 0.60 | 0.59 | 0.63 |
| ***Green vegetables*** | 0.14 | 0.46 | 0.12 | 0.43 | 0.16 | 0.48 | 0.12 | 0.40 | 0.19 | 0.53 | 0.09 | 0.37 | 0.19 | 0.53 |
| ***Vitamin A-rich fruits*** | 0.01 | 0.11 | 0.01 | 0.12 | 0.01 | 0.11 | 0.03 | 0.16 | 0.01 | 0.10 | 0.01 | 0.09 | 0.10 | 0.10 |
| ***Other fruits*** | 0.23 | 0.46 | 0.22 | 0.43 | 0.23 | 0.49 | 0.28 | 0.50 | 0.26 | 0.53 | 0.16 | 0.40 | 0.23 | 0.44 |
| ***Meat*** | 0.00 | 0.03 | 0.00 | 0.05 | 0.00 | 0.00 | 0.10 | 0.07 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ***Flesh meat*** | 0.10 | 0.31 | 0.11 | 0.32 | 0.09 | 0.30 | 0.12 | 0.33 | 0.09 | 0.29 | 0.09 | 0.29 | 0.11 | 0.33 |
| ***Eggs*** | 0.01 | 0.09 | 0.01 | 0.09 | 0.01 | 0.10 | 0.02 | 0.15 | 0.01 | 0.07 | 0.01 | 0.09 | 0.00 | 0.00 |
| ***Fish*** | 0.90 | 0.95 | 0.89 | 0.95 | 0.91 | 0.95 | 0.89 | 0.93 | 0.85 | 0.93 | 0.92 | 0.97 | 0.92 | 0.96 |
| ***Legumes*** | 0.57 | 0.54 | 0.58 | 0.53 | 0.56 | 0.55 | 0.57 | 0.52 | 0.52 | 0.53 | 0.57 | 0.58 | 0.61 | 0.52 |
| ***Milk*** | 0.01 | 0.10 | 0.01 | 0.09 | 0.01 | 0.11 | 0.02 | 0.15 | 0.02 | 0.12 | 0.00 | 0.00 | 0.00 | 0.07 |
| ***Oil*** | 0.92 | 0.33 | 0.91 | 0.33 | 0.93 | 0.33 | 0.92 | 0.37 | 0.89 | 0.35 | 0.93 | 0.3 | 0.94 | 0.31 |
| ***Sweets*** | 0.05 | 0.23 | 0.05 | 0.22 | 0.05 | 0.24 | 0.04 | 0.2 | 0.07 | 0.25 | 0.04 | 0.19 | 0.07 | 0.27 |
| ***Sweet beverages*** | 1.05 | 0.81 | 1.08 | 0.83 | 1.03 | 0.80 | 1.08 | 0.83 | 1.08 | 0.82 | 1.02 | 0.77 | 1.06 | 0.83 |
| ***Total number of food items*** | 7.29 | 2.07 | 7.17 | 2.09 | 7.40 | 2.05 | 7.66 | 2.11 | 7.34 | 2.22 | 6.89 | 1.82 | 7.45 | 2.12 |
| ***Total number of food groups*** | 4.76 | 1.16 | 4.73 | 1.89 | 4.78 | 1.13 | 4.89 | 1.24 | 4.68 | 1.15 | 4.59 | 1.12 | 4.92 | 1.12 |
| ***Total number of healthy food items*** | 4.33 | 1.50 | 4.24 | 1.55 | 4.40 | 1.44 | 4.54 | 1.41 | 4.25 | 1.60 | 4.15 | 1.45 | 4.46 | 1.50 |
| ***Total number of healthy food groups*** | 2.94 | 0.87 | 2.93 | 0.91 | 2.95 | 0.84 | 3.09 | 0.96 | 2.84 | 0.87 | 2.80 | 0.84 | 3.07 | 0.80 |

***Table 13.02*** Micronutrients, separately for boys and girls and learners attending different grades

| | Total sample | | Boys | | Girls | | Grade 1 | | Grade 2 | | Grade 3 | | Grade 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| ***Transferrin*** | 9.14 | 1.84 | 9.09 | 1.79 | 9.13 | 1.82 | 9.21 | 2.01 | 8.92 | 1.92 | 9.25 | 1.67 | 9.00 | 1.64 |
| ***Vitamin D*** | 20.10 | 0.79 | 20.24 | 10.11 | 19.88 | 9.66 | 20.58 | 10.07 | 19.06 | 10.18 | 20.46 | 10.35 | 19.93 | 8.59 |
| ***Zinc*** | 17.17 | 4.29 | 17.01 | 4.41 | 17.20 | 4.27 | 16.92 | 4.39 | 16.16 | 3.85 | 17.21 | 4.28 | 18.05 | 4.60 |
| ***Vitamin A*** | 7.19 | 3.86 | 7.10 | 3.89 | 7.16 | 3.84 | 7.02 | 3.74 | 6.66 | 3.92 | 7.17 | 4.04 | 7.61 | 3.61 |



***Figure 13.03*** Different food groups consumed during the past 24-hours on household level (parental report), for the total sample




## *Results*

Data based on child self-reports of dietary behaviour was available for 923 learners at baseline. All of the children reported that they got something to eat the night before the data assessment. Approximately 5% of the children reported that on the day before the data assessment, they only got one meal. Three quarters of the children (74.3%) got two meals, whereas 20.9% got three or more meals (Figure 13.02).

Parental reports were completed by 843 parents or guardians. Approximately 80% of the parents/guardians had the feeling that all of their household members have access to enough food on every day (Figure 13.02). Approximately one of eight parents/guardians (12.7%) reported that in the past 30 days, some members of the household went to sleep at night hungry because there was not enough food. Finally, 6.8% of the parents/guardians felt that during the past 30 days, some household members went a whole day and night without eating anything at all because there was not enough food.

Information with regard to food groups consumed is presented in Figure 13.03. The most frequently consumed food groups were cereals (98.5%), oil (90.4%), legumes (55.0%), fish (50.3%), and vegetables (48.8%). Table 13.01 shows how many food items were consumed per food group (more detailed information about specific food items consumed is presented in at the end of this chapter in Table 13.03). On average, children consumed 7.29 food items from 4.76 different food groups. For none of the food groups, differences were found between boys and girls. By contrast, learners attending grade 1 or grade 4 had higher dietary diversity compared to peers from grade 2 or grade 3, in the sense that they consumed more overall and healthy food items from more food groups.

Micronutrient status was assessed in 974 children. Almost all children (99.8%) presented with a vitamin A deficiency. No significant differences were observed between boys and girls or children from different school grades. With vitamin D status, approximately three of four children (74.2%) presented with a deficiency. Again, no significant differences were seen between boys and girls or children from different school grades. A different (and somewhat unexpected) picture emerged for zinc. While a deficiency was observed in 16.3% of the children, most of the participants (59.0%) had abnormally high zinc levels. While boys (19.1%) tended to be more likely to have a zinc deficiency than girls (13.8%), girls (62.1%) were more likely to have abnormally high zinc levels than boys (55.6%). No differences were found between students from different school grades. Finally, with regard to iron, a deficiency was found in 69.3% of the children, with boys and girls and children from different school grades being similarly represented in the deficient group. Descriptive statistics for micronutrients are shown in Table 13.02. No significant differences were found between boys and girls in any of the micronutrients. While zinc was lowest in grade 2 learners (M=16.16, SD=3.85), grade 4 learners presented with the highest scores (M=19.93, SD=8.59). A detailed overview of all consumed food items is provided in Table 13.03.

***Table 13.03*** Consumed food items, separately for boys and girls and learners attending different grades

| | *Total sample* | | *Boys* | | *Girls* | | *Grade 1* | | *Grade 2* | | *Grade 3* | | *Grade 4* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *n* | *%* | *n* | *%* | *n* | *%* | *n* | *%* | *n* | *%* | *n* | *%* | *n* | *%* |
| *Cereals. white roots and tubers* | | | | | | | | | | | | | | |
| ***Bananas (cooked)*** | 87 | 10.3 | 36 | 9.0 | 51 | 11.5 | 20 | 10.8 | 21 | 10.9 | 29 | 11.0 | 17 | 8.5 |
| ***Cassava (boiled / fried)*** | 46 | 5.5 | 17 | 4.2 | 29 | 6.6 | 8 | 4.3 | 14 | 7.3 | 14 | 5.3 | 10 | 5.0 |
| ***Chapati*** | 9 | 1.1 | 7 | 1.7 | 2 | 0.5 | 1 | 0.5 | 3 | 1.6 | 2 | 0.8 | 3 | 1.5 |
| ***Pilau (spice mix with meat)*** | 2 | 0.2 | 1 | 0.2 | 1 | 0.2 | 0 | 0.0 | 1 | 0.5 | 0 | 0.0 | 1 | 0.5 |
| ***Potato*** | 35 | 4.2 | 17 | 4.2 | 18 | 4.1 | 7 | 3.8 | 7 | 3.6 | 10 | 3.8 | 11 | 5.5 |
| ***Sorghum porridge*** | 16 | 1.9 | 8 | 2.0 | 8 | 1.8 | 5 | 2.7 | 4 | 2.1 | 3 | 1.1 | 4 | 2.0 |
| ***Ugali, based on corn meal*** | 575 | 68.2 | 269 | 67.1 | 306 | 69.2 | 131 | 70.8 | 133 | 69.3 | 177 | 67.0 | 134 | 67.0 |
| ***White bread / bread rolls*** | 5 | 0.6 | 3 | 0.7 | 2 | 0.5 | 3 | 1.6 | 0 | 0.0 | 1 | 0.4 | 1 | 0.5 |
| ***White rice*** | 739 | 87.7 | 343 | 85.5 | 396 | 89.6 | 167 | 90.3 | 164 | 85.4 | 230 | 87.1 | 176 | 88.0 |
| ***Yam*** | 1 | 0.1 | 1 | 0.2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.5 |
| ***Other cereal product*** | 12 | 1.4 | 4 | 1.0 | 8 | 1.8 | 6 | 3.2 | 3 | 1.6 | 2 | 0.8 | 1 | 0.5 |
| *Vegetables* | | | | | | | | | | | | | | |
| ***Bean/pea leaves*** | 20 | 2.4 | 9 | 2.2 | 11 | 2.5 | 6 | 3.2 | 6 | 3.1 | 4 | 1.5 | 4 | 2.0 |
| ***Cabbage*** | 11 | 1.3 | 3 | 0.7 | 8 | 1.8 | 2 | 1.1 | 2 | 1.0 | 3 | 1.1 | 4 | 2.0 |
| ***Carrot*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Cassava leaves*** | 23 | 2.7 | 11 | 2.7 | 12 | 2.7 | 8 | 4.3 | 3 | 1.6 | 6 | 2.3 | 6 | 3.0 |
| ***Chilli*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Cucumber*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Chinese lettuce*** | 110 | 13.0 | 53 | 13.2 | 57 | 12.9 | 22 | 11.9 | 22 | 11.5 | 36 | 13.6 | 30 | 15.0 |
| ***Eggplant*** | 5 | 0.6 | 3 | 0.7 | 2 | 0.5 | 1 | 0.5 | 1 | 0.5 | 1 | 0.4 | 2 | 1.0 |
| ***Kale (Sukumawiki)*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Lettuce*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Mnavu (local spinach)*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Mushrooms*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Nyanya chngu (African eggplant)*** | 19 | 2.3 | 9 | 2.2 | 10 | 2.3 | 3 | 1.6 | 4 | 2.1 | 5 | 1.9 | 7 | 3.5 |
| ***Okra*** | 27 | 3.2 | 8 | 2.0 | 19 | 4.3 | 6 | 3.2 | 6 | 3.1 | 7 | 2.7 | 8 | 4.0 |
| ***Onion*** | 31 | 3.7 | 13 | 3.2 | 18 | 4.1 | 5 | 2.7 | 12 | 6.3 | 4 | 1.5 | 10 | 5.0 |
| ***Pepper (green / red)*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Pumpkin*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Pumpkin leaves*** | 107 | 12.7 | 46 | 11.5 | 61 | 13.8 | 31 | 16.8 | 21 | 10.9 | 31 | 11.7 | 24 | 12.0 |
| ***Spinach*** | 95 | 11.3 | 47 | 11.7 | 48 | 10.9 | 15 | 8.1 | 24 | 12.5 | 32 | 12.1 | 24 | 12.0 |
| ***Sweet potato leaves*** | 45 | 5.3 | 19 | 4.7 | 26 | 5.9 | 13 | 7.0 | 7 | 3.6 | 12 | 4.5 | 13 | 6.5 |
| ***Other fresh vegetables*** | 26 | 3.1 | 11 | 2.7 | 15 | 3.4 | 5 | 2.7 | 11 | 5.7 | 3 | 1.1 | 7 | 3.5 |
| *Fruits* | | | | | | | | | | | | | | |
| ***Avocado*** | 3 | 0.4 | 1 | 0.2 | 2 | 0.5 | 0 | 0.0 | 1 | 0.5 | 2 | 0.8 | 0 | 0.0 |
| ***Banana*** | 83 | 9.8 | 43 | 10.7 | 40 | 9.0 | 21 | 11.4 | 19 | 9.9 | 21 | 8.0 | 22 | 11.0 |
| ***Baobab*** | 1 | 0.1 | 1 | 0.2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.5 |
| ***Dates*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Grapefruit*** | 2 | 0.2 | 1 | 0.2 | 1 | 0.2 | 0 | 0.0 | 1 | 0.5 | 1 | 0.4 | 0 | 0.0 |
| ***Grapes*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Jackfruit*** | 1 | 0.1 | 1 | 0.2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.5 |
| ***Lemon*** | 1 | 0.1 | 0 | 0.0 | 1 | 0.2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.5 |
| ***Mango*** | 2 | 0.2 | 1 | 0.2 | 1 | 0.2 | 1 | 0.5 | 0 | 0.0 | 0 | 0.0 | 1 | 0.5 |
| ***Papaya*** | 9 | 1.1 | 5 | 1.2 | 4 | 0.9 | 4 | 2.2 | 2 | 1.0 | 2 | 0.8 | 1 | 0.5 |
| ***Pear*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Pineapple*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Plums*** | 1 | 0.1 | 1 | 0.2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.4 | 0 | 0.0 |
| ***Orange*** | 64 | 7.6 | 27 | 6.7 | 37 | 8.4 | 21 | 11.4 | 17 | 8.9 | 12 | 4.5 | 14 | 7.0 |
| ***Sugar Cane*** | 8 | 0.9 | 3 | 0.7 | 5 | 1.1 | 2 | 1.1 | 1 | 0.5 | 3 | 1.1 | 2 | 1.0 |
| ***Tamarind*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Watermelon*** | 9 | 1.1 | 4 | 1.0 | 5 | 1.1 | 0 | 0.0 | 2 | 1.0 | 3 | 1.1 | 4 | 2.0 |
| ***Other fruit*** | 5 | 0.6 | 0 | 0.0 | 5 | 1.1 | 3 | 1.6 | 0 | 0.0 | 1 | 0.4 | 1 | 0.5 |
| ***Milk, milk products and eggs*** | | | | | | | | | | | | | | |
| ***Cheese*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Eggs*** | 7 | 0.8 | 3 | 0.7 | 4 | 0.9 | 4 | 2.2 | 1 | 0.5 | 2 | 0.8 | 0 | 0.0 |
| ***Egg products*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Ice cream*** | 9 | 1.1 | 5 | 1.2 | 4 | 0.9 | 3 | 1.6 | 1 | 0.5 | 3 | 1.1 | 2 | 1.0 |
| ***Milk (cow)*** | 8 | 0.9 | 3 | 0.7 | 5 | 1.1 | 4 | 2.2 | 3 | 1.6 | 0 | 0 | 1 | 0.5 |
| ***Milk (other)*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Legumes, nuts and their products*** | | | | | | | | | | | | | | |
| ***Beans (dried/tinned)*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Cashew*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Groundnuts (bambara)*** | 2 | 0.2 | 0 | 0.0 | 2 | 0.5 | 2 | 1.1 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Groundnuts (other)*** | 25 | 3.0 | 12 | 3.0 | 13 | 2.9 | 7 | 3.8 | 6 | 3.1 | 8 | 3.0 | 4 | 2.0 |
| ***Lentils*** | 3 | 0.4 | 1 | 0.2 | 2 | 0.5 | 0 | 0.0 | 0 | 0.0 | 1 | 0.4 | 2 | 1.0 |
| ***Peas (black-eyed)*** | 49 | 5.8 | 22 | 5.5 | 27 | 6.1 | 8 | 4.3 | 9 | 4.7 | 20 | 7.6 | 12 | 6.0 |
| ***Peas (fresh)*** | 3 | 0.4 | 2 | 0.5 | 1 | 0.2 | 0 | 0.0 | 0 | 0.0 | 2 | 0.8 | 1 | 0.5 |
| ***Peas (pigeon)*** | 162 | 19.2 | 80 | 20.0 | 82 | 18.6 | 32 | 17.3 | 28 | 14.6 | 55 | 20.8 | 47 | 23.5 |
| ***Soybeans*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Other legumes*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Flesh meat, organ meat, fish*** | | | | | | | | | | | | | | |
| ***Beef and veal*** | 73 | 8.7 | 38 | 9.5 | 35 | 7.9 | 21 | 11.4 | 16 | 8.3 | 18 | 6.8 | 18 | 9.0 |
| ***Chicken*** | 8 | 0.9 | 3 | 0.7 | 5 | 1.1 | 1 | 0.5 | 1 | 0.5 | 3 | 1.1 | 3 | 1.5 |
| ***Duck*** | 1 | 0.1 | 1 | 0.2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.4 | 0 | 0.0 |
| ***Fish (dried)*** | 71 | 8.4 | 34 | 8.5 | 37 | 8.4 | 23 | 12.4 | 17 | 8.9 | 17 | 6.4 | 14 | 7.0 |
| ***Fish (fresh, Sardines)*** | 31 | 3.7 | 20 | 5.0 | 11 | 2.5 | 4 | 2.2 | 11 | 5.7 | 5 | 1.9 | 11 | 5.5 |
| ***Fish (fresh, other)*** | 328 | 38.9 | 151 | 37.7 | 177 | 40.0 | 69 | 37.3 | 68 | 35.4 | 110 | 41.7 | 80 | 40.0 |
| ***Gastrointestinal parts*** | 1 | 0.1 | 1 | 0.2 | 0 | 0.0 | 1 | 0.5 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Goat*** | 1 | 0.1 | 1 | 0.2 | 0 | 0.0 | 1 | 0.5 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Kidney*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Lamb*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Pork*** | 4 | 0.5 | 3 | 0.7 | 1 | 0.2 | 0 | 0.0 | 1 | 0.5 | 2 | 0.8 | 1 | 0.5 |
| ***Rabbit*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Sausages, boerewors*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Other*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Beverages, sweets, oil*** | | | | | | | | | | | | | | |
| ***Animal fat*** | 9 | 1.1 | 4 | 1.0 | 5 | 1.1 | 3 | 1.6 | 2 | 1.0 | 3 | 1.1 | 1 | 0.5 |
| ***Butter*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Cake, doughnuts, tarts*** | 2 | 0.2 | 0 | 0.0 | 2 | 0.5 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 2 | 1.0 |



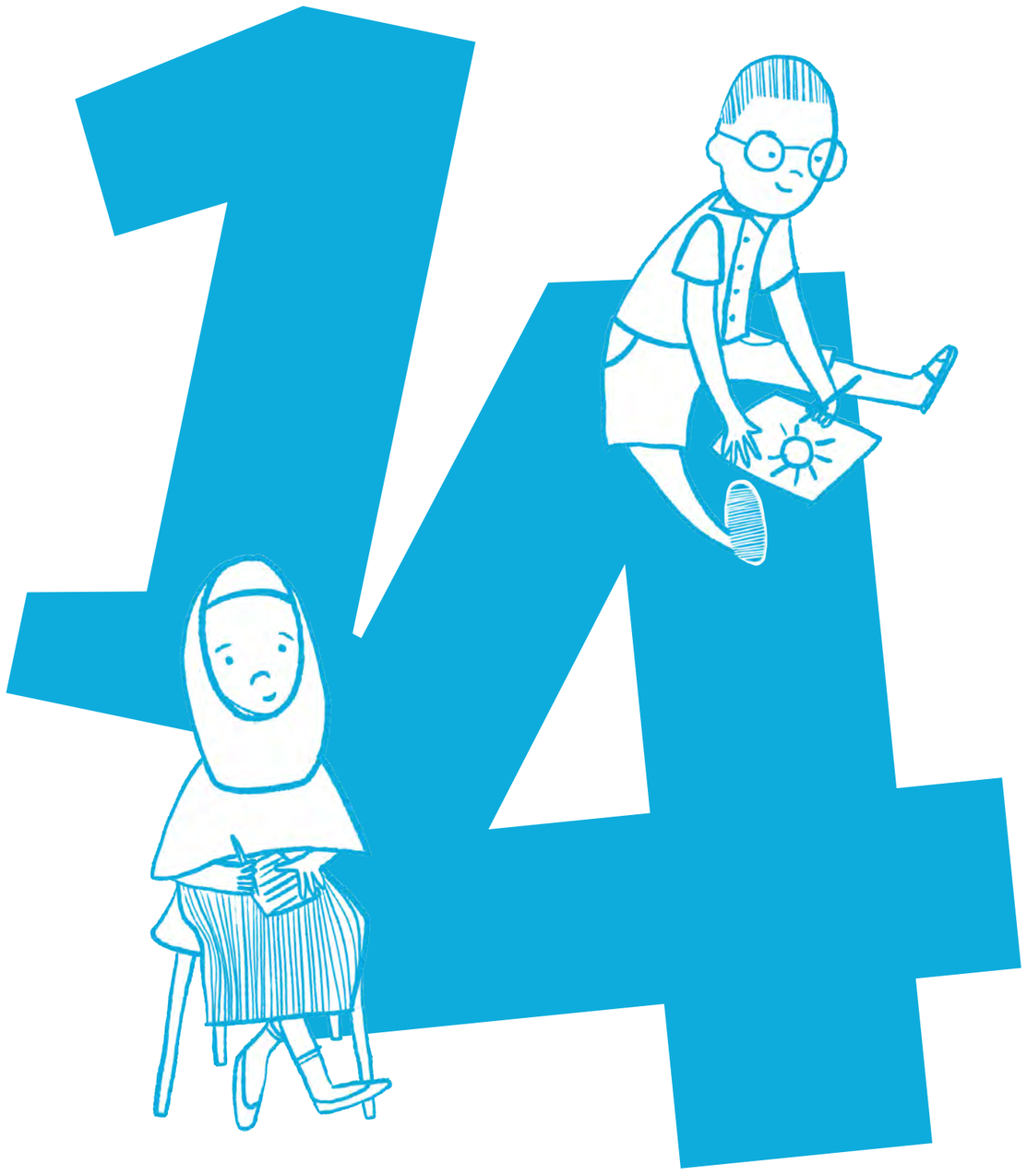
| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Candies, lollipops*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Chocolates*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Cookies, biscuits*** | 20 | 2.4 | 9 | 2.2 | 11 | 2.5 | 4 | 2.2 | 8 | 4.2 | 4 | 1.5 | 4 | 2.0 |
| ***Coconut milk*** | 14 | 1.7 | 5 | 1.2 | 9 | 2.0 | 6 | 3.2 | 2 | 1.0 | 2 | 0.8 | 4 | 2.0 |
| ***Honey*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Juice (100% fruit)*** | 18 | 2.1 | 9 | 2.2 | 9 | 2.0 | 7 | 3.8 | 9 | 4.7 | 0 | 0.0 | 2 | 1.0 |
| ***Juice (sweetenend fruit drink)*** | 23 | 2.7 | 10 | 2.5 | 13 | 2.9 | 6 | 3.2 | 9 | 4.7 | 5 | 1.9 | 3 | 1.5 |
| ***Maandazi*** | 58 | 6.9 | 23 | 5.7 | 35 | 7.9 | 17 | 9.2 | 17 | 8.9 | 14 | 5.3 | 10 | 5.0 |
| ***Margarine*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Mineral water*** | 1 | 0.1 | 1 | 0.2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.4 | 0 | 0.0 |
| ***Oil (coconut)*** | 2 | 0.2 | 1 | 0.2 | 1 | 0.2 | 0 | 0.0 | 0 | 0.0 | 2 | 0.8 | 0 | 0.0 |
| ***Oil (palm)*** | 104 | 12.3 | 57 | 14.2 | 47 | 10.6 | 28 | 15.1 | 24 | 12.5 | 30 | 11.4 | 21 | 10.5 |
| ***Oil (peanut)*** | 4 | 0.5 | 1 | 0.2 | 3 | 0.7 | 0 | 0.0 | 1 | 0.5 | 2 | 0.8 | 1 | 0.5 |
| ***Oil (sunflower, vegetable)*** | 752 | 89.2 | 355 | 88.5 | 397 | 89.9 | 162 | 87.6 | 167 | 87.0 | 238 | 90.2 | 183 | 91.5 |
| ***Oil (other)*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Sugar*** | 9 | 1.1 | 5 | 1.2 | 4 | 0.9 | 1 | 0.5 | 3 | 1.6 | 1 | 0.4 | 4 | 2.0 |
| ***Soft drinks*** | 14 | 1.7 | 8 | 2.0 | 6 | 1.4 | 3 | 1.6 | 4 | 2.1 | 3 | 1.1 | 4 | 2.0 |
| ***Tea*** | 173 | 20.5 | 86 | 21.4 | 87 | 19.7 | 40 | 21.6 | 38 | 19.8 | 49 | 18.6 | 46 | 23.0 |
| ***Vitumba*** | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| ***Water*** | 574 | 68.1 | 272 | 67.8 | 302 | 68.3 | 123 | 66.5 | 132 | 68.8 | 181 | 68.6 | 137 | 68.5 |
| ***Other*** | 1 | 0.1 | 0 | 0.0 | 1 | 0.2 | 0 | 0.0 | 0 | 0.0 | 1 | 0.4 | 0 | 0.0 |

## *Conclusion*

With regard to food security, a relatively positive picture emerged. Thus, most of the children reported that they got more than one meal the day before the data assessment. Similarly, only a relatively small percentage of parents/guardians reported that some household members had to go to bed hungry or had to go a whole day without food. The most frequently consumed food groups were cereals, oil, legumes, fish, and vegetables. On average, children consumed approximately seven different food items from four different food groups per day. With regard to micronutrient status, many children presented with vitamin A (99.8%), vitamin D (74.2%), and iron (69.3%) deficiencies. With regard to zinc, a deficiency was observed in 16.3% of the children, whereas more than half of the participants had abnormally high zinc levels (59.0%).

***On average, children consumed approximately seven different food items from four different food groups per day.***

# *Intervention and project implementation*



As part of the KaziAfya project, the funder (Fondation Botnar) commissioned two independent experts (Asinath Rusibamayila, Harvard University School of Public Health, and Angel Dillip, Apotheker Tanzania) to carry out a so-called Mid-term evaluation. The primary objective of this evaluation was to better understand the intervention and its context and to enhance the impact that goes beyond the funding period itself. For sustainable impact, it was suggested to develop a Theory of Change. The secondary objective was to evaluate how the project considered fair principles of partnership and collaboration based on the Research Fairness Initiative and KFPE principles.

To better understand the project and implementation status, the two experts reviewed all relevant project documents including the study proposals that were submitted to Fondation Botnar and local ethical boards, IHI IRB oversight report, progress reports, project milestones, and the project budget. In addition, focus group discussions (n=9) and in-depth interviews (n=13) were carried out with school children, teachers and staff, project grantees, parents/ guardians of school children, micro-nutrient suppliers, project partners, and relevant health and education authorities within and outside the project area.

The key findings of the Mid-term evaluation are summarized in the following three sections.

***The primary objective of this evaluation was to better understand the intervention and its context to enhance the impact that goes beyond the funding period itself.***



***Asinath Rusibamayila***

Asinath Rusibamayila, based in Seattle, Washington, United States, is currently a Product Manager at Sanofi Pasteur, bringing experience from previous roles at Harvard University, Columbia University, Columbia University Mailman School of Public Health and Massachusetts General Hospital: Cost-Effectiveness of Preventing AIDS Complicati. Asinath Rusibamayila holds a 2016–2020 Doctor of Public Health (DrPH) @ Harvard T.H. Chan School of Public Health. She has a robust skill set that includes Public Health, Global Health, Epidemiology, Literature Reviews, Program Evaluation and more. Asinath Rusibamayila contributes valuable insights to the industry.



***Dr. Angel Dillip***

Dr. Angel Dillip is a public health specialist with diverse experience in community and health system research. Angel has worked on several social science interventions focusing on social underpinnings of ill-health and access to care. She has mainly worked on malaria, maternal, child and adolescent health, HIV, antimicrobial resistance, pharmaceutical systems and non-communicable disease. Angel is a member of several Technical Working Groups of the Ministry of Health. She is a co-founder and Director of Programs at Apotheker Health Access Initiative and lecturer at Nelson Mandela African Institution of Science and Technology in Tanzania. Angel holds a PhD in Epidemiology and Public Health (2012) from the University of Basel, Swiss Tropical and Public Health Institute, Switzerland.



## *14.1. Conditions for successful intervention implementation*

### *a. Individual level*

#### *Parents*

Parents are key stakeholders in this project because they are the primary decision-makers for children under 18 years of age. Getting the parents' understanding and ownership of the intervention is fundamental for the uptake and sustainability of the project. Both parents have to be involved in the process of recruiting children into the study because in the Kazi-Afya program there were incidences of one parent agreeing to their child partaking in the intervention and then the other parent going back to ask that their child be removed from the study. At the beginning of the project, there was a lot of resistance and hesitation from some parents because of a lack of understanding of the use of tools like the Actigraph belts children were made to wear to measure their level of physical activity. The actigraph belts were feared by parents to cause sterility in young boys and infertility in girls. Parents were also skeptical of their children potentially receiving the nutritional supplements. This greatly dissuaded many parents from joining the KaziAfya project initially. Heightened myths around various interventions could be contextual to Ifakara. The presence of a research institution like IHI (formally known as Stiff) in Ifakara means that many projects and programs have been conducted in the community and so people sometimes fear being used as 'guinea-pigs' especially if they are unclear of the research purpose and value. Building trust through community awareness, working with community and government leaders as well as providing incentives that cater to the needs of the people is key. One key success of the KaziAfya project, which was an unintended or unplanned consequence, was providing free health care for children enrolled in the project. The cost of healthcare is a huge burden for low-income parents. Parents were inclined to have their children enrolled in the KaziAfya project with the incentive of free health care for the duration of the intervention.

#### *Students*

Coaches and teachers reported that enrolled KaziAfya children greatly enjoyed the physical education classes and being part of the project. They looked forward to the physical education sessions, especially the dancing-to-music classes. Teachers felt that the KaziAfya program had contributed to an overall improvement in school attendance for the students because they looked forward to days when they had physical education classes. However, there were

Distribution of supplements

Parent surveys

School kids walking home

Boys physical education class

some gender differences noted in the ability of the students to participate fully in the physical education sessions. Slightly older female students were noted to become shy and reserved in participating in some of the activities. For example, adolescent girls thought that they were too mature dancing in front of others in the moving-to-music classes that involved creativity in dancing moves. The lack of appropriate sporting outfits for girls is another challenge. Girls wear skirts as school uniforms and schools do not have the practice of having children bring separate outfits for physical education. Moreover, many schools depending on the conditions of their restrooms do not have appropriate spaces to change clothes. As the teachers expressed, some of the designed exercises require students to rest on the floor and raise their legs. Girls are not able to participate in these activities effectively while wearing skirts.

### *b. School-level*

#### *Physical education teachers*

The national guidelines in Tanzania are that every primary school should have two physical education teachers and also have scheduled physical classes. However, the implementation of these national guidelines in government primary schools is very poor for several reasons. Firstly, physical education teaching is not a professionalized position in schools. Many times, physical education teachers are hired without any required training or experience in the subject. The reality in most cases is that physical education teachers are appointed from the pool of existing teacher staff based on interest or availability to teach the class. Without the experience and training, physical education teachers do not teach physical education. The time that is usually scheduled for physical education is considered a break period where students are allowed to go out and play on their own, without supervision or any physical education curriculum.



***There needs to be educational advocacy with teachers on how physical activities do not distract students from focusing on their studies but can have a positive influence in increasing attentiveness and motivation to attend school.***

Secondly, because these physical education teachers are appointed from the pool of teaching staff, they often already must teach other classes and physical education is habitually a deprioritized lesson. The high workload of the teachers is very limiting and so the common case is that physical education teachers in public primary schools are just figureheads and do not play much of a role in teaching the classes. The number of physical education teachers is also a limiting factor. Public primary schools in Tanzania have large numbers of students and a single class can have more than 50 students. It is difficult for one teacher to effectively teach and coordinate a physical education class with such high numbers of students. Building professionalism in physical education instruction is important. Teachers recruited into these positions need to either have training or experience in physical education. Also, the workload of these teachers should be evaluated to ensure that they have time and interest in teaching the subject.

Teachers in general are supportive of students participating in physical education activities but some of them raised concerns that physical activities can distract students from their other studies. This is often the general thinking in the Tanzanian education system where physical education is seen as an 'extra' but not a priority for the children's growth and learning. There needs to be educational advocacy with teachers on how physical activities do not distract students from focusing on their studies but can have a positive influence in increasing attentiveness and motivation to attend school.

### *Materials and equipment*

KaziAfya has been able to provide materials such as balls, ropes, and a speaker/radio for the physical education classes. Most of these materials are stored in the schools for example in the headmaster's office. However, in some of the schools, the teachers complained that the equipment is not sufficient given the high number of students. For example, teachers complained how in one school they would have three to four balls/ropes but there are about 80 students per class, and making sure that all the students get a turn is quite difficult. As well to be able to scale-up the intervention to whole schools, then there is a need for more equipment. Maintenance and upkeep of this equipment are also key. For example, when balls get lost or something stops working, schools are not able to fix or replace the equipment because they currently have no budget for such incidents.


▲ Physical education equipment per school

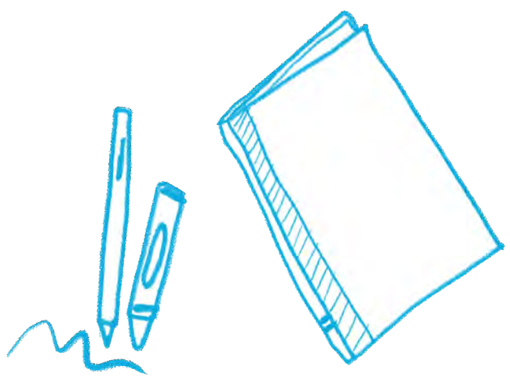
### *School committees*

School committees which consist of parent representatives, teachers, and recognized members of society are important stakeholders in the uptake of educational interventions like KaziAfya. These committees are often tasked with reviewing and approving various projects and activities relating to the schools. Getting their ownership and buy-in is key. School committees were involved at the beginning of the KaziAfya project. They were invited to a meeting with the district representative, teachers, and project staff were told about the intervention. They played a role during school government inspections and could attest that they were aware of the project and can confirm that the KaziAfya staff were following protocol.

▲ A school

### *School environment and operation*

Having sufficient space for physical activities is a challenge in some schools. For example, the schools that are in the town area do not have sufficient playing grounds to accommodate a large number of students in the schools. This can be limiting for the teachers, as they are forced to find places to play such as under trees. The area also has to have sufficient shade because Tanzania in general is very hot and humid. Unfortunately, physical education classes are often scheduled in the afternoon, and students and teachers are not able to participate effectively in the outside activities due to scorching heat. Moreover,





in the afternoon, students are often already hungry and many, if not most do not have lunch provisions either from home or the schools. Programming and scheduling for classes are often done by the headteacher in partnership with a few teachers in the school. Physical education coaches are not always given a say in the programming and this is a problem because afternoons are too hot and it is also a time when students are also starting to get hungry, making it difficult for them to focus and have the energy to participate effectively in the physical activities.

## *c. Health-system level*

### *Nurse*

The KaziAfya project hired a full-time nurse whose mandate was to oversee the overall health of the children in the duration of the project including providing support to navigate access to health care. Parents would contact the nurse for any ailments the child has for example fever, malaria or a broken leg, etc. The mandate of the nurse is to confirm the identity of the child, that they are part of the KaziAfya project. Once confirmed, the nurse would work with the parent to escort the child and link them to care. The access to healthcare navigation provided by the nurse was a valued asset to parents and children and became an incentive for parents to want their children to be part of the KaziAfya intervention. For the project, the nurse also helped to document all the healthcare spending incurred in the children's visits.

> ***The goal is to help schools position themselves to take responsibility for the physical education and nutrition aspects of the project.***

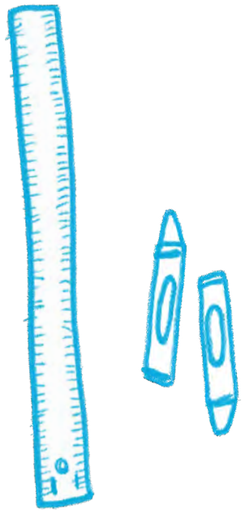
### *Health insurance*

Parents who were first very skeptical about the project due to fear of infertility myths later changed their minds after hearing of how KaziAfya children were receiving free health care from the project. Providing health insurance was not the original design of the project. However, in the approval process of the project, when NIMR learned that the nutritional supplements were new and had not been in the market, it required IHI to change the design of the project from a randomized control trial to a clinical study. Clinical trials have very different requirements from other studies and one of the new requirements was to provide health insurance to study participants. The KaziAfya project lead in Tanzania worked with a former IHI employee who was a clinical study specialist to find a provider for health insurance. IHI negotiated with the funders for increased funding of $6500 to buy health insurance for the children. However, there was an oversight in the contract with the health insurance company. In the contract, the health insurance company was only meant to cover health costs incurred by the children as a direct impact of the study. For example, in the event, a child hurts themselves during physical activities. This contract was not properly understood by the Tanzanian project leads and so it was communicated to the parents that all KaziAfya children would receive health insurance for the duration of the study. Parents began sending their sick children to the KaziAfya-hired nurse for any kind of ailments, project or non-project related. The nurse would then help coordinate care for the child by taking the child to the hospital and also the pharmacy. She would then document and report back to the KaziAfya project staff on the type of care received by the child as well as cost. The KaziAfya project staff would then work on reimbursing the hospital (St. Francis) and the Pharmacy (Silver Pharmacy) for the health services and medication respectively. Parents greatly valued the free health services and also care coordination support they received from the Kazi Afya project. Many parents who had refused their children to participate in the project came back to request they join after hearing of the free health service benefits provided. Access and affordability to healthcare is a huge need for rural communities and therefore providing this has been a great incentive for the uptake of the project.

### *d. Community level*

#### *Community leaders and committee*

At the community level, the KaziAfya project did not involve many stakeholders. Only community representatives who were part of the school committee were informed of the project. At the community level, there are often many influential figures, for example, ward and village leaders who have a lot of formal or informal authority and can act as great resources to help build trust with parents and children and also support to educate and demystify notions around the intervention. Parents highlighted that KaziAfya project staff were not well known by people. The recommended that the project staff should work more closely together with influential people in the community or respective government leaders. People are more likely to accept or trust a project once they see someone influential standing up and talk confidently about the project.



KaziAfya kids



### *e. District level*

#### *Town educational and medical officers*

At the district level, some educational officers are responsible for giving approval and overseeing NGOs or research-based projects happening in the community. Ownership of the interventions at this level is very important because, in the event of any negative outcomes or misunderstandings in the community, they are often called upon to broker such situations. At the beginning of the KaziAfya project, invited key stakeholders at the district level including the educational and health officers to inform them about the project and get their sign-off. This is often a standard protocol that many projects and research interventions have to do before entering the community to initiate any projects. However, it is important to continue to keep these stakeholders informed. For example, in the case of KaziAfya, staff conducted a meeting at the beginning of the project to introduce the intervention to these key district officials, however, they never followed up with them. Unfortunately, there was a large change of administration at the district and town levels and so the new district leaders had not been informed or appraised of the project. Usually, the district educational officers appoint and assign a coordinator to each project in the community, but since this person was not aware of the project, he did not assign an officer at the district level to oversee the KaziAfya project.

As much as the district authority supports and values the importance of the KaziAfya project, there is no harmonization on similar projects working at the school level in the district. The same was highlighted by the coaches and teachers that, there is another USAID-funded project, named “Coaching Boys into Men” which also has a physical education component and provides sportswear and relevant equipment to school children. Coaches, in particular, reported challenges in responding to many questions from teachers and school children as to why KaziAfya is not providing sportswear to children like the other project. Harmonization of such projects at the district level could reduce duplication of similar approaches, planning on how best such interventions could complement each other to ensure effective implementation and sustainability beyond project life.

### *f. Regional/national level*

#### *Training schools for physical education teachers*

Currently, there are very few schools that provide professional training for physical education teachers. For example, one district educational officer mentioned a training program in Shinyanga or Simuyu, but there does not seem to be sufficient locations. Most of the times, physical education instructors get their training from make-shift NGO-provided short-term courses. To build more professionalism into physical education instruction, there needs to be more training centers for individuals interested in instructors for physical education.

***Harmonization of such projects at the district level could reduce duplication of similar approaches, planning on how best such interventions complement each other to ensure effective implementation and sustainability beyond project life.***

***Table 14.01*** Overview of conditions for successful intervention implementation

| | *Challenge or need* | *Inputs/activity* | *Resources/leverage* | *Outcome* | *Impact* |
|---|---|---|---|---|---|
| ***Parents*** | Fear and myths around the intervention or tools<br><br>Uninformed about the value and benefits of the intervention | Conduct educational workshops that focus not only on the value of the intervention but also on demystifying myths<br><br>Provide incentives that cater to the real needs of the people (e.g., healthcare or food lunches for the children) | Work with teachers and trusted leaders of the community and government who have formal or informal authority in the society to build trust and relationship with parents<br><br>Provision of a nurse or provider to support children health needs | Informed, and increased uptake of the study<br><br>Both parental consent and support of their child partaking in the study | Improve health and well-being of children |
| ***Children*** | Hunger or lack of energy to participate in physical activities<br><br>Differences in gender engagement in the activities | Provide lunch or nutritional supplements<br><br>Conduct physical education sessions in the morning<br><br>Provide suitable sportswear for girls and if possible, for boys as well<br><br>Ensure availability of appropriate changing rooms | Physical education teachers should work with headteachers and government educational officers to ensure that physical education classes are scheduled at a time that is suitable for playing outside, e.g. mornings and not afternoons in the scorching sun<br><br>Work with school committees to raise funds to ensure students, especially girls have appropriate outfits for exercise<br><br>Sensitize parents through different channels to support their children with sports wear | All children (female and male) participate effectively in the physical activities | Improve health and well-being of children |
| ***Physical education teachers/Head teachers*** | Lack of professionalism in the cadre<br><br>Insufficient number of physical education teachers<br><br>High workload for the teachers | Recruitment of physical education teachers should be a formalized process with educational or experiential requirements for the hire<br><br>Review policies to increase numbers of people studying physical education | Headteachers need to work with district government heads on guidelines for hiring physical education teachers<br><br>Create accountability of teaching physical education through school policies or working with educational officers and inspectors and ensure they are enforcing the practice of teaching physical education sessions | Hiring of professional physical education teachers with respective training or education<br><br>Physical education instructors focus on only teaching physical education<br><br>Lower ratio of physical education teachers per student | Improve health and well-being of children |
| ***Physical education courses/ sessions*** | Scheduling of physical education<br><br>Materials and playing area | Work with health teachers and government educational officers to advocate for the scheduling of physical education in the mornings times when the weather is conducive, and students are not yet tired and hungry<br><br>Look for a large space for a playground and work with school administration and children to plant trees for shade<br><br>Increase the supply of materials and equipment for physical education and build a budget for maintenance of such equipment | Partner with headteachers and others in the scheduling of courses.<br><br>Work with school leadership (health teachers and school committees) as well as government town/district educational officers about finding appropriate land for the school playgrounds<br><br>Work with donors or district officials or even parents about building a budget for buying and maintaining sports equipment | Better engagement of children during PA sessions<br><br>Availability of a suitable area with sufficient shade and space for physical education<br><br>Sufficient equipment like balls and ropes to match the number of students. | Improve health and well-being of children |
| ***Health benefits*** | Provision of health benefits (either access to care coordination or provision of free health services and medication) | Provide basic health insurance.<br><br>Provision of free health services, as well as coordinated care provided by a nurse has been an instrumental incentive or a positive (unintended) consequence of the project | District insurance coordinators promote enrolment of students into different health insurance schemes. | Increase in health-seeking behavior | Improve health and well-being of children |
| ***Community leaders and committees (school committees/ town educational and health officers)*** | Build ownership of the intervention at community level | Conduct stakeholder mapping to find out key leaders with formal or informal authority in the community who would be important to be involved in the project<br><br>Conduct initial workshop and meetings to introduce them to the study and get their formal approval or consent<br><br>Organize periodic (quarterly or biannual or annual) follow-up visits or field visits with the stakeholders to appraise them on project milestones | Start with a recognized local government official at the community level (e.g. village/ ward leaders), and work with them to identify other key individuals and influential people and committees that need to be aware of the research | A good partnership with key community stakeholders who can help bridge relationships and ownership of the project with the intended audience | Improve health and well-being of children |
| ***District educational and health officers including district medical officer (DMO)*** | Get consent and also build ownership of the intervention<br><br>Harmonization of similar interventions at the district level | Conduct initial workshop and meetings to introduce research personnel to the district and get their formal approval or consent<br><br>Organize periodic (quarterly or biannual or annual) follow-up visits or field visits with the stakeholders to appraise them on project milestones<br><br>Bring together all stakeholders working on similar interventions at the district for prioritization and planning | Project staff should work with district educational and health officials to identify relevant district authorities to participate in project meetings and project harmonization activities<br><br>Conduct quarterly progress meetings with relevant stakeholders working on similar interventions in the district for planning and prioritization of activities | Strong ownership of the project from the district level for sustainability | Improve health and well-being of children |
| ***National*** | The perception that physical education is not as important as other subjects in the curriculum<br><br>Accountability measures for national guidelines on physical education | Create minimum requirements for physical education teachers (training or experience) to build professionalism<br><br>Have national curriculums for physical education and create mandates or policies that physical education has to be taught and is not a free period for students to do as they want | Use current structures for accountability measures that are used for other subjects like math and science should also be applied to physical education<br><br>For example, education inspection officers who visit schools to check that teachers are present and teaching required curriculum for subjects like mathematics should also inspect physical education | Physical education is seen as a valued and prioritized coursework for children in primary schools | Improve health and well-being of children |

## *14.2. Partnerships and collaboration*

The second objective of the Mid-term evaluation was to assess the partnerships within the KaziAfya project. The project is a collaboration between the Department of Sport, Exercise, and Health at the University of Basel (DSBG) along with the Swiss TPH in Switzerland, CSRC in Côte d'Ivoire, Ifakara Health Institute (IHI) in Tanzania and NMU in South Africa. For this report, we evaluated the partnership and collaboration between DSBG and IHI and applied a SWOT (Strengths, Weaknesses, Opportunities, and Threat) framework to better understand how the partnership has worked, related challenges, and existing opportunities to improve the future collaborations.

### *Strengths*

#### *a. Mutual learning*

The partnership between IHI, DSBG and the other institutions has created avenues for mutual North-South and South-South learning. IHI, as a research institution has research scientists with strong technical background compared to the teams in the other partner countries (South Africa and Cote d'Ivoire). IHI statisticians and researchers have helped to teach and introduce research methods to the teams in DSBG and also the other partnering countries. For example, an IHI research scientist was able to teach prinicipal component analysis to the teams in Switzerland and South Africa to apply in their research.

#### *b. Scientific collaboration*

There has been good ownership and sharing of data and research opportunities. The research teams in Tanzania have equal access to the data and the ability to choose a topic of interest to publish. The teams have an agreement that if a person is interested in publishing a particular topic, they inform the rest of the members within their local teams but also the investigators in Switzerland. This creates transparency and opens the doors if there is interest in collaboration.

#### *c. Local ownership*

The Tanzanian IHI team has felt empowered and been given the leeway to lead the project with minimal supervision. The local team does not feel micro-managed. When issues arise, the IHI personnel communicate the challenges to DSBG and advise on solutions and a way forward. For example, when the study changed from a randomized trial to a clinical study, there was a requirement to give the study participants health insurance. IHI was able to negotiate with DSBG and the funders to get extra funding to pay for the insurance. When the health insurance supplier could not cater to some of the children's ailments due to a contractual misunderstanding, IHI took the liberty to devise an alternative means and communicate that to DSBG and the funders.



### *Weaknesses*

#### *a. Lack of understanding of the nature of organizations*

IHI is a research institution with running costs and no 'free' labor. On the other hand, DSBG is a university with avenues for 'free' labor through masters and doctoral students. This difference in the nature of organizations brought some tension at the beginning of the partnership while negotiating contractual agreements. Understanding the nature of the organizations and the difference in the needs can help with smoother negotiations and the creation of more equitable agreements.

#### *b. Communication and feedback systems*

Formal communication and check-ins between IHI and DSBG were arranged to be at least twice a week but this did not happen. Most of the check-ins were informal through WhatsApp, but this at times did not allow for collective reporting and decision making to happen. However, both organizations felt that they were able to acquire information needed whenever they needed it.

#### *c. Adaptation to local text*

The study was meant to be a comparative study between the study countries (Tanzania, Côte d'Ivoire, and South Africa), and so there was a need to have similarities in the study design and also measurement tools. However, some of the questions for example were irrelevant to the local context and the IHI team wanted to adapt the questions, and this caused some tensions in the beginning. As well, the Tanzanian context was observed to be different because of the high number of students in a class compared to few and manageable in countries like South Africa. The Tanzanian team suggested a slightly different design that involved grouping the students into smaller teams to make it more manageable to teach the physical education classes. However, this was not the decided-upon design and the IHI team had to push for a slight redesign of the project. Some of these tensions could be avoided by involving all the partners from the very beginning. Partners need to be involved in setting the agenda and designing the tools and questionnaires before project implementation starts.

A classroom

## *Opportunities*

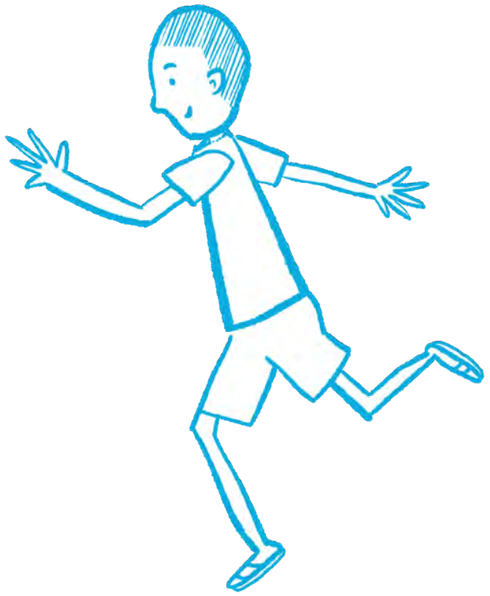
### *Cross-disciplinary learning*

The DSEH team, along with the IHI have research scientists with varied research training, experience, and interest. While some are more focused on physical education research, others on nutrition, sleep, and malaria. There is room for more cross-disciplinary learning and collaboration that can happen across borders.

## *Threats*

### *Lack of follow-through with contractual agreements*

In the original negotiations of the contracts between DSBG and IHI, it was agreed that IHI would have two research scientists on a full-time basis as part of the KaziAfya project. One PhD-student and one post- doctoral fellow. However, later DSBG learnt that Lina's commitment changed from 50% to 20% which was less time commitment than what had been agreed upon. Despite this change, DSBG trusts that the KaziAfya project is being run effectively by the IHI team.



▲ Kids at school



## *Discussion and conclusion*

The Tanzania KaziAfya team has been successful to create uptake of the research in Ifakara and build increased interest in the project despite many of the parents' initial hesitation. The provision of free health services coupled with the coordinated care offered by the project nurse was a great motivator for parents allowing their children to join the clinical trial. The logistical problems of not getting the nutritional supplements in time have limited the design of the project to some extent. However, finally on the 13th of February 2021, the supplements arrived in Tanzania and from the 19th of February they were being distributed weekly to teachers to provide to children in the MNMM and combination arms of the intervention. One foreseen challenge is Ramadan, a fasting period for Muslims. For Muslim families including children observing the fast cannot eat anything during the day including the nutritional supplements. This may pose as a challenge for the subset of participants who are Muslim in the study. The nutritional supplements are valuable to the implementation of the study not just for research purposes but also can help manage the challenge of children feeling hungry or tired during afternoon physical education classes. However, the scale-up of nutritional supplements would also require a lot of education to the parents to prevent misinformation from arising. Involving more community leaders and stakeholders in the outreach to parents can help to build trust and also to assist in creating awareness against myths and rumors concerning nutritional supplements as well the physical education.

> ***Involving more community leaders and stakeholders in the outreach to parents can help to build trust.***

Readiness for scale-up and sustainability of physical education in primary schools is still low despite the successful uptake and implementation of the intervention. The infrastructure and enabling environment in Tanzania are not well set-up for teaching physical education in primary schools due to a lack of implementation and accountability systems. There are good national policies and guidelines around having physical education teachers and also scheduled physical education classes, but implementation is poor. There first needs to be a mindset shift at the school, community, and national level on the importance and value of physical education to children's overall health and well-being. Physical education in schools has to be taken as a 'serious' subject that is equally important to course like math and science. Accountability measures that are used by the government to oversee curriculums and teaching of other courses need to also be applied to teaching of physical education. For example, there are school inspection officers who usually pay surprise visits to schools to ensure that teachers are present and teaching required classes. The same precedence is not given for physical education classes. Physical education teachers are appointed, but not obligated to teach during periods scheduled for the course.

Moreover, Tanzania primary schools need to build curriculums for physical education classes that are easy to follow and teach given the constraints of high numbers of students and also a lack of sufficiently spacious playgrounds in some schools. Teachers have expressed being overwhelmed due to the high workload with other coursework. Most schools hire only two physical education teachers who are supposed to teach all grades and many times they are also teaching other subjects. To help manage the workload and also the high number of students, schools can either hire more teachers if they can afford it or find ways of getting teaching assistance either from other support teachers or using students from higher grades. The challenge of scheduling physical education at an appropriate time is also crucial. The climate and weather in most parts of Tanzania are quite hot and humid, making it unbearable to have outside activity and exercise in the afternoon. Therefore, it may help to have these classes scheduled in the morning.

The findings from the evaluation show that girls, especially those in the adolescent age are shyer and more reserved from participating in some of the physical education programs such as dancing to music. Adolescence is a transition period where most children, girls in particular are very self-conscious of the changes in their body. Having some theory lessons in the physical education sessions that can help students understand these changes in their body's may be helpful. However, this will need to be permitted and consented to with the national education guidelines on age and culturally appropriate lessons that can be taught. Girls also need sport-appropriate gear to be able to participate effectively in the physical education classes. This can appear as an easy solution but for most rural families affording a pair of school uniform can be a considerable cost. Schools as well need to have the infrastructure for clean and spacious restrooms for changing. Table 14.01 highlights a sort of action chain, with hierarchy of activities that could done to ensure sustainability of the approach.

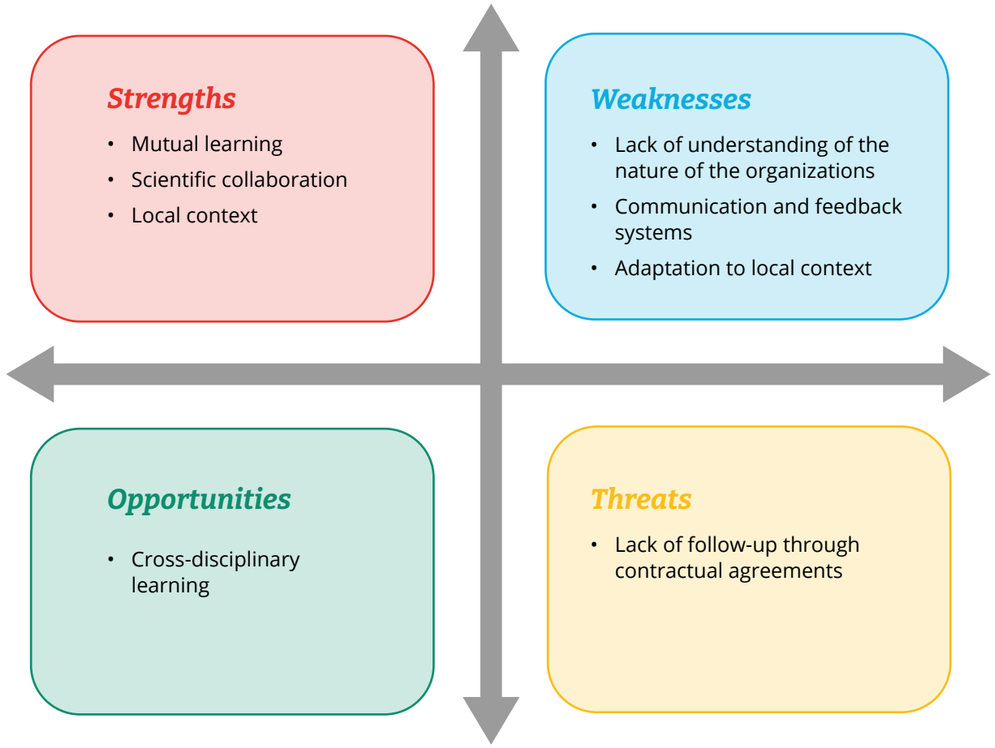
Overall, the KaziAfya project provides valuable research, to establish evidence on the importance of physical education to the health and well-being of children. Research findings need to be disseminated at the ministry level to help create better guidelines and policies around physical education. The findings need to be translated to create awareness at the individual, school, community and health system level so that students, parents, and teachers can appreciate the value of physical education in schools.

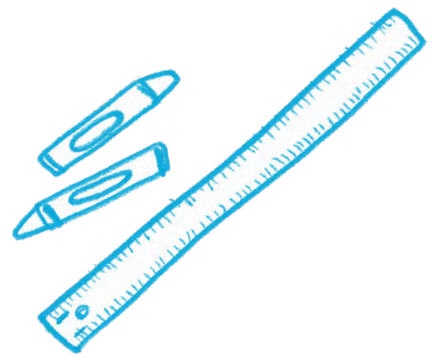
***The KaziAfya project provides valuable research to establish evidence on the importance of physical education to the health and well-being of children.***

Umvubo



*Figure 14.01* SWOT analysis of the project partnership



# *Concluding remarks and acknowledgments*

The KaziAfya project was the first randomized placebo-controlled double-blind design study, conducted among public primary school in Kilombero district, in the Southeastern part of Tanzania.The project was perceived positively by the parents, local leaders, teachers and education authorities expressed an interest to pursue this program in the long term. The KaziAfya project stands as a beacon of progress in addressing the health challenges faced by schoolchildren in low- and middle-income countries. This effort has provided insight into the effectiveness of school-based treatments and their potential to improve the well-being of our young people through thorough scientific investigation and community involvement. We sincerely thank all the people and organizations whose steadfast support enabled the KaziAfya project.

We express our sincere appreciation to Mrs. Witness Kimoleta the Kilombero District Department of Education for her invaluable assistance and cooperation throughout the project. Our profound thanks go to the parents, students and principals, teachers of Miembeni (Mr Romwald Richard), Katindiuka (Mrs Respiciosa Gaudence), Kibaoni (Mr Kembamba Mbarouk), and Kining'ina (Mr Renatus Mdumula) primary schools for their enthusiastic participation and unwavering commitment to the study.

We also acknowledge with deep appreciation the dedicated efforts of the field workers, research assistants, and all members of the project teams involved in data collection, analysis, and implementation. Their tireless dedication and professionalism have been instrumental in the success of this endeavor. Moreover, we express our gratitude for the financial support generously provided by the Foundation Botnar (Basel, Switzerland), facilitating the execution of this research endeavor. Their investment in our vision has not only yielded invaluable insights but has also significantly contributed to the advancement of scientific knowledge in the domain of child health and well-being.

In addition, we extend our appreciation for the fruitful scientific collaboration between the Ifakara Health Institute, Department of Sport, Exercise and Health of the University of Basel, and the Swiss Tropical and Public Health Institute. Their ongoing collaboration and support have been instrumental in our efforts. Together, we can persist in making meaningful strides towards enhancing the health and future prospects of children worldwide.

# *Publications, theses and presentations*



## *Publications in peer-reviewed journals*

Minja, E. G., Mrimi, E. C., Mponzi, W. P., Mollel, G. J., Lang, C., Beckmann, J., Gerber, M., Pühse, U., Long, K.Z., Honorati, M., Okumu, F., Finda, M & Utzinger, J. (2024). Prevalence and Determinants of Undernutrition in Schoolchildren in the Kilombero District, South-Eastern Tanzania. Tropical Medicine and Infectious Disease, 9(5), 96.

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## *Master's theses*

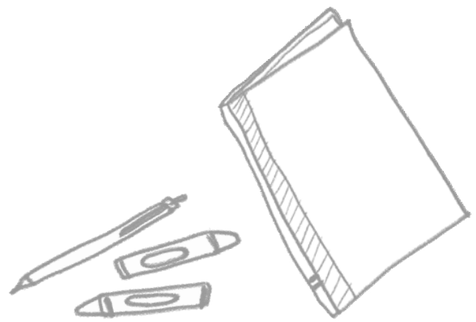
Mr. Fahad Mwakalebela: Association between physical activity and the health and well-being of schoolchildren in Ifakara town council Tanzania. Status: ongoing (graduation date: planned for June 2024)

## *PhD theses*

Ms. Elihaika Minja: Effect of a school-based health intervention program on micronutrient status and physical activity in Kilombero district, Tanzania. Status: ongoing (graduation date: planned for 2026)

## *Presentations and posters at national and international conferences*

Minja E., Mrimi C, Lang C, Gerber M, Utzinger J & Long, K. KaziAfya: Impact of a school-based health intervention program on body composition among Tanzania primary schoolchildren. American Society of Tropical Medicine and Hygiene (ASTMH) November 13-17, 2024, New Orleans, Louisiana. Presenting author (Poster)



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