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NUTRITIONAL STATUS OF SCHOOLING CHILDREN IN TANZANIA AND UGANDA: RESEARCH AND ACTION

.

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To Agnese, Arianna and Andrea.
Thank you for your understanding,
support and tolerance.

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1. INTRODUCTION

1.1 OVERVIEW

Nutrition has been defined as the 'science of food, the nutrients and other substances therein, their action, interaction and balance in relation to health and disease, and the processes by which the organism ingests, absorbs, transports, utilizes and excretes food substances' (Lagua and Claudio, 1995). Any deviation from a balanced intake of food in relation to the body's dietary needs is called malnutrition, which is so defined as 'inadequate or excess intake of protein, energy and micronutrients such as vitamins, and the frequent infections and disorders that result' (WHO, 2000).

Malnutrition – with its two different faces of 'undernutrition', the outcome of insufficient food/micronutrients intake and repeated diseases, and 'overnutrition', overconsumption of food leads to an increase of the risks of non-communicable diseases and is currently considered one of the most important causes of death and disability worldwide (WHO, 2013a). It has been estimated that globally some 2-3 billion people are experiencing some form of malnutrition, i.e. are either overweight, undernourished, or have some sort of micronutrient deficiency (International Food Policy Research Institute, 2014).

The majority of data used for epidemiological and demographic analysis on LMICs come from the internationally-coordinated household surveys, such as the USAID-supported Demographic and Health Surveys (DHS) (https://dhsprogram.com/) and the UNICEF-supported Multiple Indicator Cluster Surveys (MICS) (https://www.unicef.org/statistics/index_24302.html) and are related to children 0-5 years old. These data are very relevant to national and global decision making, as they are used for planning health programs, social policies, and for monitoring interventions' effectiveness. DHS and MICS surveys are carried on every 3-4 years and collect numerous data on mother/child health and their socio-economic status. However, such important amount of information regards a short period of a child life and data about older children are largely absent.

High malnutrition prevalence is observable all over the world but with different distributions according to the specific type of malnutrition considered. Overnutrition and obesity mostly occur in North America, Europe and western Pacific regions (cumulatively called High-Income Countries), although in the last decade a worrying increment of the prevalence of overweight/obesity in children and adults is discernible also in Low- and Middle-Income Countries (LMICs) (Ng et al., 2014) (Figure 1.1). This phenomenon is related to the progressive abandonment of traditional diets and the concomitant adoption of a Western-type life style, including an increase in the consumption of cheap, high-calories but low-quality foods. Furthermore, more sedentary habits with respect to the past lead to a general decrease in daily energy expenditure, which in turn contributes to a considerable development of overweight and obesity (Popkin, 1994; Popkin et al., 2012). In 2014, more than 1.9 billion adults (39%), 18 years and older, have been estimated to be overweight, over 600 million (13%) of whose obese. Also, some 42 millions of children under the age of 5 are overweight or obese (UNICEF et al., 2016). Finally, if we consider both children and adults, the worldwide prevalence of obesity has doubled between 1980 and 2014, an alarming trend which calls for urgent action (http://www.who.int/mediacentre/factsheets/fs311/en/).

While overnutrition and undernutrition are generally geographically and socially separated problems, they have recently been observed to coexist within the same family or ethnic/geographic groups, usually with adults presenting overnutrition problems and children suffering from undernutrition. This paradoxical situation is called ‘dual burden household’ (Popkin et al., 1996; Caballero, 2005; Doak et al., 2005; Popkin et al., 2012). Because of a general rapid change in dietary habits and in life style (a phenomenon defined “nutrition transition”), the dual burden household must be considered a cultural and health phenomenon, which is likely on the rise (Black et al., 2013; Hidalgo et al., 2014; Tzioumis and Adair, 2014; Wojcicki, 2014) and needs to be further studied and tackled in order to delineate opportunities for intervention and prevention.

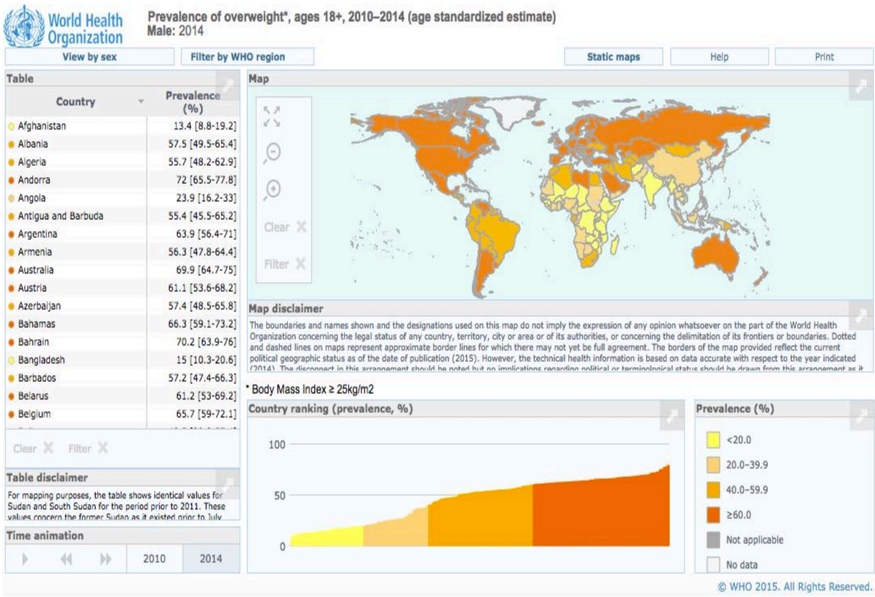

Figure 1.1. Prevalence and distribution of overweight in the world. Source: WHO

Focusing now our attention on undernutrition, this mostly affects children, especially during the first period of their life. It has been estimated that 45% of under-five mortality is attributable to undernutrition (Black et al., 2013). Distribution of children undernutrition is, in some way, complementary to that of overnutrition, being sub-Saharan African and South Asian countries the geographical areas with the higher prevalences (Figure 1.2). Prevalence of children undernutrition changes according to the different indices used. If we consider the low height for age (stunting), 156 million on children under five were estimated to be stunted in 2015, while 50 million were the children with a low weight for height (wasting) (UNICEF et al., 2016).

Undernutrition prevalence is globally reducing, but in some parts of the world (Eastern, Northern and Western Africa, Caribbean and Central America) only modest or little progresses have been observed. In Africa, in particular, the decline of stunting has been lower respect to other areas. Furthermore, due to the population growth, the absolute number of stunted children is increasing (de Onis and Branca, 2016 and references within).

Due to this reason, the efforts by several countries and international associations to meet the challenge of children undernutrition have never been so intense (UNICEF, 2013; Gillespie et al., 2013; Holdsworth et al., 2015) and "[…] nutrition has consequently been elevated up the global development agenda, as the era of the post-Millennium Development Goals approaches," (Arthur et al., 2015).

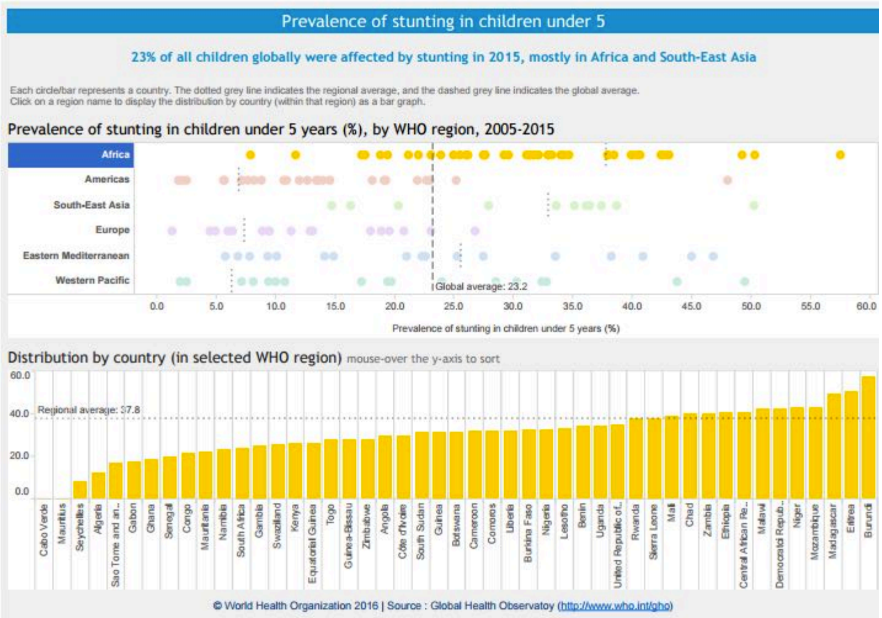

Figure 1.2. Prevalence of stunting (low height for age) in different countries. Source: WHO

For this reason, the resolution adopted in 2012 by the WHO on maternal, infant and young child nutrition included six global targets to hold the world accountable for reducing malnutrition (WHO, 2012). First, and most important of those targets was the reduction by 40% of the number of stunted children under 5 years of age by 2025. Furthermore, the sixth of the targets was to reduce and maintain childhood wasting to less than 5%. However, for the problems already explained, also child overweight has been considered a problem to be seriously tackled, so that the fourth of the WHO Global targets is “No increase in childhood overweight by 2025 (WHO, 2012).

Why it is so important to fight against children malnutrition? It has been undoubtedly observed and verified that poor fetal growth or undernutrition during the first 2 years of a child’s life lead to irreversible damages in childhood and in adolescence and important consequences in mature age (Victora et al., 2008; Arthur, 2015). Undernutrition in fact, is associated with increasing risk of chronic diseases and susceptibility to infections, blindness, and anemia (Victora et al., 2008). Moreover, malnutrition can affect cognitive development impairing school attention, school performance and future productivity of a person and, consequently, of an entire country (Victora et al. 2008; Arthur et al., 2015; de Onis and Branca, 2016). Several studies indicate significant association between physical growth, schooling and cognition (Victora et al., 2008). For example, it has been demonstrated a negative association between stunting values and verbal and math scores (Fink and Rockers, 2014). Thus, it is quite evident that tackling malnutrition is a way to let children have proper growth and a chance for a better future means to give to a whole country a chance for a better future.

Starting from 2000, the Millennium Summit of the United Nations, following the adoption of the United Nation Millennium Declaration, established the Eight International Development Goals for the 2015 (UN, 2013). The first of these Millennium Development Goals (MDGs) was indeed to “Eradicate extreme poverty and hunger”, and “halve, between 1990 and 2015, the proportion of people who suffer from hunger” (specific target 1.C) as evaluated by means of the “prevalence of underweight children under-five years of age” (indicator 1.8). Starting from the 2015, within the 17 Sustainable Development Goals of Post-2015 Agenda identified for improving equity to meet the needs of most disadvantaged people, improve nutrition and, particularly end hunger represents, again, one of the most important challenges (http://www.un.org/sustainabledevelopment/sustainable-development-goals/). The 17 UN_Sustainable Development Goals together with the 6 WHO Global Targets to improve maternal, infant and young child nutrition, represent a concrete commitment, of the main international agencies, to address and finally successfully fight this important issue.

Which are the determinants of children malnutrition? Socio-economic causes, and in particular the wealth status of the families pay a fundamental role (Arthur, 2015; UNICEF, 2013; de Onis et a., 2011; Chirande et al., 2015). Poverty is one of the key constraints because mothers and caregivers are often unable to put into practice even the basic cares for a proper growth of the child (Victora et al., 2008; de Onis and Branca, 2016). Mothers education is another key factor in determining a child nutritional status and mothers deeply influence children nutritional status starting from the way and/or the period they breastfeed and wean their children (UNICEF, 2013a).

1.2 UNDERNUTRITION IN AFRICA

As already reported, in the last decades an important decrease of children undernutrition prevalence has been observed worldwide, and it can be considered an indication of improvements in the overall socio-economic conditions of a number of countries (Chirande et al., 2015). However, if we take in account the global variation of the prevalence of stunting (low height for age) we can see that it ranges from 5 to 65% among the less-developed countries (de Onis et al., 2011). In other words, the reduction of undernutrition has not been homogeneous in all areas. It has been estimated that there are 171 millions of stunted children 0-5 years worldwide, 98% of which reside in developing countries and about 35% in Africa (de Onis et al., 2011; Chirande et al., 2015). Moreover, although stunting prevalence is decreasing in Africa, because of expanding population the number of African stunted 0-5 year children increased from 51 million in 2000 to 60 million in 2010. If present trends do not change, these numbers are estimated to increase up to 64 million in 2020 (de Onis et al., 2011). Also the prevalence of underweight and the general micronutrient deficiencies did not change substantially (UNSCN, 2010, Steven et al., 2012). Overall, countries in sub-Saharan Africa (SSA) show the worst condition of children undernutrition, displaying insufficient progress in achieving the first MDG.

However, also within Africa different scenarios are observable since the decline in stunting has been found to be greatest in the northern and central regions, while it has hardly changed in the eastern, western, and southern regions (Chirande et al., 2015; de Onis et al., 2011).

Because of the implications of poor nutrition for individuals and society, there is awareness that poor nutritional status is hindering development of these countries. For this reason, besides multiple challenges that Africa is facing on economic, political and social aspects, efforts on nutrition research are considered of the outmost importance (Holdsworth et al., 2015). Several national and international organizations, universities, research centres, NGOs, governments and donors are working together for realizing nutrition policies in most African countries. For example, the African Regional Nutritional Strategy for 2005-2015 (African Union, 2005), adopted by the African Ministers of Health and Heads of State of the African Union (Holdsworth et al., 2015) represents an interesting approach to tackle the problem of children malnutrition at the continent level. When targeted well, research can indeed play a crucial role in improving nutritional status. However, most of the research efforts are not still providing evidence for cost-effective interventions that can prevent malnutrition in all its forms (Lachat et al., 2015; Holdsworth et al, 2015).

The weak points coming out from a general analysis on the way in which the problem of child malnutrition has been traditionally faced, are mainly some incoherencies between the importance recognized for research or general efforts on problems linked to nutrition and the low investments on nutrition. It also emerges a need for research that would contribute to the evidence base of effective interventions (WHO, 2013b).

Surely, the voice of African stakeholders should be heed with greater attention in order to address nutritional challenges. SSA stakeholders should identify priority actions and research to be done and redirect funds towards them. Finally, more attention and funds should be invested in behavioral and ecological nutrition (the impact of environmental and behavioral changes on nutritional status) and promote multidisciplinary collaborations between nutritionists, social scientists, agricultural and environmental scientists (Holdsworth et al., 2015).

1.3 UNDERNUTRITION IN TANZANIA AND UGANDA

Tanzania

Tanzania, is ranked third among leading countries in stunting in sub-Saharan Africa after Ethiopia and the Democratic Republic of Congo (Semali et al., 2015), thus is quite evident that children undernutrition is a problem that must be tackled seriously.

According to the data reported in the last Tanzania Demographic and Health Survey (TDHS, 2011), that gives a clear idea of the prevalence of children malnutrition, 42% of children under 5 are stunted and 16.5% are severely stunted, 4.8% are wasted and 1.2% are severely wasted, 15.8% are underweight and 3.8% are severely underweight.

In the last years Tanzania has made significant progresses towards achieving global and national targets in key areas of well-being, particularly in health and education (Mtega et al., 2016). So, how is it possible that the problems and issues concerning child health are still on the table?

There is common agreement that at the basis of this apparent contradiction lays the fact that Tanzania's social and economic development is challenged by sharp inequalities and heterogeneity, especially between urban and rural areas, geographical locations, and among different socio-economic groups (wealth classes). Economic disparity, in particular, leads to an unequal access to essential basic services and employment opportunities, to a gender imbalance of labor, and to different structural and social norms, as well as to unequal power relations (Mtega et al., 2016). For these reasons some of the regions affected by the higher prevalence of children undernutrition are paradoxically the same areas leading food production in Tanzania (Mtega et al., 2016). It is quite evident that sustained economic growth (about 7% in the last years) has not benefitted the majority of the population, and the poorest, the less educated and those living in rural or particular geographical areas continue to be disadvantaged (Mtega et al., 2016 and references within).

Within social economic groups, the household characteristics and the economic and educational status of individual household members, of mothers in particular, play a fundamental role in children undernutrition (Semali et al., 2015). Mother education has been frequently considered one of the most important determinant for Tanzanian children undernutrition (Kulwa et al., 2015; Semali et al., 2015). In fact, educated mothers are more likely to have a better economic situation, or have better skills to face health problems and the nutritional needs of their families (Makoka and Masibo, 2015). Poor breastfeeding practices, inadequate dietary intake during weaning, high rates of diseases, maternal inadequate nutritional knowledge and household food insecurity have been associated with stunting in Tanzania (Shimira et al., 2001; Mamiro et al., 2005; Kulwa et al, 2006; Young et al., 2010). Overall, only 2 out of 10 Tanzanian children are fed in accordance with the recommended infant and young child feeding (IYCF) practices (TDHS, 2011).

Uganda

Although rich in natural resources and presenting good conditions for agriculture, Uganda is still deeply affected by malnutrition, poverty and disease (Vogt et al, 2016).

According to the data reported in the last Uganda Demographic and Health Survey (UDHS, 2012), 33.4% of children under 5 are stunted, and 13.7% severely stunted, 4.7% are wasted and 1.5% are severely wasted, 18.8% are underweight and 3.4% are severely underweight. Undernutrition is responsible for about 35% of deaths among children under 5 (Agaba et al., 2016) and recently has been estimated that malnutrition will cost Uganda about 19 trillion Ugandan shillings (about 7.7 billion US$) in lost productivity between 2013 and 2025 (Pomeroy-Stevens et al., 2016).

Important progresses have been made in reducing HIV, malaria, and tuberculosis, and in producing food to meet the needs of people. Also, the poverty level has decreased from 39% to 23% in the period 2002-2010. (Government of Uganda, 2011). However, malnutrition prevalences have not improved much over the past 15 years, and some indicators, like micronutrient deficiency, have even worsened (Government of Uganda, 2011; UDHS, 2012; Vogt et al., 2016).

There are two main immediate causes directly responsible for child malnutrition in Uganda: inadequate dietary intake (which is in turn related to infant feeding practices) and high disease burden (mainly malaria, diarrhoea, respiratory infections) (Government of Uganda, 2011; Nankubi and Muliira, 2015). However, others social constraints deeply influence children's health and, consequently, their nutritional status, such as household insecurity, inadequate maternal and child care, poor access to health care (Government of Uganda, 2011).

About one out of four Ugandan girls 15–19 years old are already mothers, most of them being in deficit as for micronutrients or are malnourished (Vogt et al., 2016). This obviously leads to a negative vicious circle that exacerbates child malnutrition. Moreover, because of high prevalences of HIV/AIDS, diseases and poverty, 14% of all Ugandan children are orphans, thus overstretching the Ugandan child protection structures and worsening the children nutritional status (MGLSD, 2004. Vogt et al., 2016).

For all these reasons, in 2011, the government developed the Uganda Nutrition Action Plan (UNAP) (Government of Uganda, 2011). The UNAP is a national multi-sectoral nutrition plan developed by the Government of Uganda to ensure adequate food and nutrition to all Ugandans (especially infants, children and women in reproductive age) in order to improve their health. This five-year action plan is certainly an important step forward, because it sets firm points to fight malnutrition issues in the country, hopefully making the start of a new development toward a better quality of human capital and a proper socio-economic improvement.

1.4 THE IMPORTANCE OF COLLABORATION

Children's malnutrition may be fought. Despite emergencies in some parts of the world, there are examples of countries that have adopted nutrition programming that led to sustainable advances in the country's nutritional status (UNICEF, 2013a). Together with a strong government leadership, a key factor to obtain positive results is the presence of coordinated and collaborative partnerships across sectors, good technical capacity and programme design, sufficient resources to strengthen implementation. Also required is a robust monitoring and evaluation system that can be used to improve real-time programme implementation and demonstrate impact.

The role played by NGOs, in this context, is crucial. This applies as well in health research for development. "NGOs are contributing at all stages of the research cycle, fostering the relevance and effectiveness of the research, priority setting, and knowledge translation to action. They have a key role in stewardship (promoting and advocating for relevant global health research), resource mobilization for research, the generation, utilization and management of knowledge, and capacity development" (Delisle et al., 2005). To maximize the potential benefits of research, partnerships involving NGOs and academic researchers must be built on trust, transparency, respect, solidarity, and mutuality, and a number of such successful and sustainable collaborations exist (Oliver et al., 2016).

One such environments that promote and foster collaboration between academic partners, NGOs, and other stakeholders, is the Global Alliance for Improved Nutrition (GAIN) an international organization that was launched at the UN in 2002 to tackle the human suffering caused by malnutrition (http://www.gainhealth.org/). “By bringing key partners together around a common purpose — to improve nutrition — we combine our own capabilities with the individual expertise of each partner” states GAIN, further stressing the role of research “on generating and using evidence to inform program design and ensure that programs are adapted to local contextual needs” (http://www.gainhealth.org/).

1.5 THE PARTNERSHIP WITH BHALOBASA NGO

From summer 2012, our research group at the University of Cagliari started a project with Bhalobasa, a NGO based in Perignano, Italy (http://www.bhalobasa.it/). Bhalobasa promotes, since 1991, children's schooling in different parts of the world (India, Burkina Faso, Congo, Uganda and Tanzania) thanks to distance sponsorships. Moreover, it boosts microcredit projects focusing on healthcare and social fields. The most peculiar aspect of Bhalobasa is that any project and action it promotes is suggested by local partners and its concreteness and feasibility carefully evaluated. Local partners are generally teachers or headmasters or the priests of parishes. For all these reasons we thought that starting a project on children's malnutrition in collaboration with an entity such as Bhalobasa would have represented an additional value respect to a ‘normal’ research activity conducted in a poor and needy area.

In our idea, this collaboration would have allowed us to know, in detail, the local realities and to establish a true contact with people. Thanks to this collaboration, we could start an awareness campaign with parents and caregivers and, most importantly, we would have promptly and directly ‘intervene’ on those children that would have resulted malnourished from our research. Moreover, since the friendship between Bhalobasa volunteers and local partner usually lasts in time, we could have started a monitoring action for some years.

1.6 RESEARCH OUTLINE

The primary scope of this thesis was to study the nutritional status of Ugandan and Tanzanian children attending some primary schools. However, the assessment of children nutritional status is the very first step towards the final goal of tackling this problem in a wider view. In fact, we have promoted, with the concrete help of Bhalobasa NGO, awareness campaigns and projects aimed to parents, teachers, and caregivers, on the importance of a proper nutrition and a proper growth for each child for their better future, and for a better future of a whole country. Moreover, the collaboration with Bhalobasa, has allowed to start a monitoring program on the nutritional status of all the children that are attending the surveyed schools, in order to evaluate the impact of the actions we have enforced on their growth recover.

We also dealt with an important problem which can affect the possibility to evaluate a child’s nutritional status, i.e. the lack or uncertainness of birth data. Indeed, the precise knowledge of the date of birth is a fundamental prerequisite for assessing a child nutritional status because the correct age is necessary to calculate most of nutritional indices. However, the registration of children soon after their birth is not a common habit in several LMIC counties, where parents and children knowledge of birth data is pretty fuzzy. For this reasons, we have engaged in detail this problem both in our samples and in a wider geographical area.

Finally, because of the importance of a proper nutrition and a proper growth for each child, regardless of the geographical area, we have also promoted *ad hoc* projects involving Italian students, where these problems have been discussed.

In summary, the thesis outline is the following:

INTRODUCTION - This section includes an overview of data, distribution, problems and consequences related to children malnutrition. Moreover, we focused on the efforts by African and international organizations to fight malnutrition and, more in detail, on the situation of children malnutrition in Tanzania and Uganda.

THE LACK OF BIRTH DATA - The problem of how the lack or uncertainness of birth data affect malnutrition prevalence is here analyzed in detail. We have used both data retrieved from international surveys, carried on and supported by the US Agency of International Development (USAID) or by UNICEF, and data we have collected in the schools we visited.

THE ASSESSMENT OF NUTRITIONAL STATUS – During the two field surveys (August 2014 and 2015) anthropometric measurements and social information have been collected in order to assess the nutritional status of all the children attending the 5 schools we selected (4 in Uganda and 1 in Tanzania). Moreover, because collections have been performed in the same schools, a monitoring of children nutritional status have been also carried out over a one-year period. In this chapter, data, comments, comparisons with literature and discussions on this topic are reported.

AWARENESS RAISING - All the projects realized in these years, in Uganda, Tanzania, and Italy, for a better appreciation by parents, teachers, caregivers and students of the importance of nutrition for a proper child growth, are here reported and commented.

CONCLUSIONS – In this last part, the resume of the activities performed and the analysis of their impacts on children nutrition and/or caregiver behaviors and the future actions planned are reported.

2. THE LACK OF BIRTH DATA[1]

2.1 OVERVIEW

Ancient romans (since the VI century A.C.) introduced regular censuses (from the latin world "*censere*", which means "to evaluate") of the citizens on the basis of their age and socio-economic status. The imperator Augusto was fully aware of the importance of census and the implication of an efficient civil registration system for political, military and economic purpose, so to decide to extend the census system to the "universus orbis" (Scheidel, 1996).

Two thousand years later, the ambitious dream of Cesare Augusto has not been realized yet. Indeed, while rich countries can rely on accurate demographic and epidemiological information from civil registration systems, periodic censuses and health surveys, in sub-Saharan Africa and South-East Asia millions of people 'are born, and live and die uncounted and ignored' (AbouZahr et al., 2007). It has been estimated that nearly 230 millions of children under five have not their birth registered most of them coming from south east Asia and sub-Saharan Africa (UNICEF, 2013b).

Name and nationality are every child's right enshrined by of the General Assembly of the UN Human Rights Council in 2013 "Birth registration and the right of everyone to recognition everywhere as a person before the law. Registering a child's birth is the first step in securing recognition before the law, safeguarding fundamental rights.

The civil registration of vital events conveys human rights to individuals and helps with economic development. All information coming out from these data are fundamental for policy, planning, and evaluation in

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[1] Comandini O, Marini E, 2015. Gli esseri assenti. Il problema degli "invisibili" nelle indagini epidemiologiche. In "Sui Presupposti di Un Nuovo Umanesimo. Tra Ragione, Scienza e Religione". Mimesi Ed. pp: 209-223.

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Comandini O, Cabras S, Marini E, 2017. Nutritional evaluation of undocumented children: a neglected health issue affecting the most fragile people. European Journal of Public Health 27: 71-73.

all sectors of development. Health sector, particularly, should closely collaborate with registration authorities, national statistical offices, and other agencies for planning its actions effectively (AbouZahr et al., 2007).

Inefficient or inadequate civil registration systems are frequently associated with countries that have experienced (or are still experiencing) strife and conflicts, natural disasters or unstable political situations. All these conditions deeply affect the stability and the efficiency of a government. Also the gross national income per head is an important variable strictly associated with a functioning civil registration system, although with some exceptions (Setel et al., 2007). The same economical differentiation is often observed also within the countries, where birth registration rates tend to be higher in richest quintiles of the population (UNICEF, 2013b).

In the last few years, progresses, albeit small, have been achieved in raising birth registration (BR) levels. International organizations, national governments, academia and public–private partnerships have started, in the last decade, to work together for encouraging birth registration habits and facilities, promoting complementary interim measures, such as population censuses, demographic surveillance sites, household registration systems and household sample surveys (UNICEF, 2013b; World Bank and WHO, 2014).

However, the last report from UNICEF (2013b) showed that in sub-Saharan Africa still 44% of children under five have not their birth registered. Nevertheless, this region shows a quite heterogeneous scenario having some countries, such as Seychelles or Mauritius or Cabo Verde islands, with a birth registration rates ranging from 90 to 100%. On the other side, some other countries have the lowest BR rates in the world, such as Somalia (3%), Liberia (4%), Ethiopia (7%).

Besides the ethical, social and political issue of recognizing an identity to all human beings, a complete and accurate vital statistics system presents important scientific implications. For all these reasons one of the most important international scientific journal, "The Lancet", dedicated to this "scandal of invisibility", a specific series titled 'Who counts?' to denunciate the lack of vital statistics (births, deaths, and causes of death) in most developing countries of the world (AbouZahr et al., 2007; Hill et al., 2007; Horton, 2007; Mahapatra et al., 2007; Setel et al., 2007).

Despite the increasing number of researches on this topic, only a few scientific papers that consider the consequences of the scarce and vague information on children's age on the estimates of nutritional status, have been published (Bairagi et al., 1991; Bairagi and Ashan, 1998; Bairagi and Langsten, 2008). For all the reasons already explained and because of our interest in malnutrition problems in sub-Saharan area, we have decided to study in detail the effects of insufficient or imprecise age data on estimates of undernutrition prevalence in sub-Saharan African countries (Comandini and Marini, 2015, Comandini et al., 2016; 2017). In particular, we highlighted the magnitude of age error also in some real contexts, and we studied its effects on nutritional status estimates in concrete and hypothetical situations (Comandini et al., 2016; 2017).

2.2 BIRTH REGISTRATION AND CHILD UNDERNUTRITION IN SUB-SAHARAN AFRICA

Introduction

Internationally coordinated household surveys, such as the Demographic and Health Surveys (DHS) supported by the US Agency for International Development (DHS, 2014) and the Multiple Indicator Cluster Surveys (MICS) supported by UNICEF (2014a), provide international political and academic organizations the great majority of epidemiological and demographic data on low- and middle-income countries.

These data are widely used by governments and development agencies for planning and monitoring health programs and social policies. DHS and MICS are based on robust sampling techniques, with a multistage cluster sample design planned to reach a complete coverage of the population residing in households (Eisele et al., 2013). Moreover, these data are comparable to each other, the MICS and DHS sampling procedures being harmonized (Hancioglu and Arnold, 2013). However, household survey estimates can be affected by a certain level of sampling (selection bias) and non-sampling error, i.e. information bias and information error (Eisele et al., 2013).

Selection bias affects DHS and MICS estimates because the surveys may under-represent insecure areas and slum-dwelling populations, and by design they omit parts of the population (people who are more likely to be at risk of undernutrition) such as the homeless, refugees, nomadic people, and those living in residential care facilities, long stay hospitals or orphanages (Carr-Hill, 2013; Eisele et al., 2013; Hancioglu and Arnold, 2013). Moreover, in the case of nutritional analysis, a coverage bias occurs because children without a 'valid date of birth – month and year' have a zero probability of selection. However, children with quite accurate age data, such as those with their births registered, cannot be representative of the whole population since children from the richest segments of society, or children who have a well-educated mother, are more likely to be registered and receive adequate nutrition (UNICEF, 2005; 2013b). On the other hand, the age of unregistered children is subject to both information bias and error. In fact, where birth registration (BR) is uncommon, the age of children must be estimated by asking their parents or careers, who may not be able to provide reliable information. Further, age data from surveys are frequently rounded up or down to the nearest year or half-year because of age-heaping errors introduced by interviewers (Alderman, 2000).

The aim of this research was to study the effect of selection bias, information bias and information error, due to insufficient or imprecise age data, on undernutrition estimates. Such errors predominantly affect those regions where the coverage of BR is incomplete, thus causing a drawback of 'uncounted people' still not described.

The problem is discussed using DHS and MICS data from sub-Saharan Africa. This geographic area was selected considering the availability of published data, the high prevalence of undernutrition and low

BR rates, and in order to reduce the confounding effects due to intercontinental variability.

Methods

Data have been retrieved from the DHS (http://www.dhsprogram.com) and MICS (http://www.childinfo.org/mics.html) reports, where the results of the surveys are freely available, and from the DHS and MICS datasets, where the actual individual data can be obtained upon permission.

DHS and MICS data include birth registration rate (BR), calculated as the number of children whose births have been registered on the total number of children surveyed, and nutritional indices calculated according to WHO criteria (WHO, 1995). The analyses are focused on children under five years of age.

The more recent DHS and MICS reports where birth registration rate (BR) and malnutrition levels were contextually present, and with the sample subdivision in wealth quintiles, have been used.

The subdivision in quintiles is based on the wealth index, i.e. “a composite measure of a household's cumulative living standard” (DHS, 2013). This index does not provide absolute information on poverty, but is considered the best option to account for within-country socioeconomic variability (Gwatkin et al., 2007; Barros and Victora, 2013)

Weight measurements are obtained using mother–infant scales. Standing height is taken for children older than 24 months, while younger children are measured lying down on the board (recumbent length). Particular attention is given to the collection of age data, by checking consistency between answers to different questions (age of the child, date of birth, birthday) and with dates reported within certificates, when available. The analysis of birth history, where women report the details of each live birth separately, and of the contraceptive calendar represents a further probe for age quality. In some countries, the use of calendars of events, i.e. customized historic calendars with dates of significant events for each geographic area and even for each ethnic or religious group within each country, contributes to reduce errors in estimating a child's date of birth (FAO, 2008).

The different indicators of undernutrition – stunting, underweight and wasting – are defined as, respectively, the prevalence of children with height-for-age, weight-for-age and weight-for-height below -2 SD from the median value of the standard (i.e. height-for-age Z-score (HAZ), weight-for-age Z-score (WAZ) and weight-for-height Z-score (WHZ) <–2) (WHO, 1995).

In the present study the indices based on the WHO Child Growth Standards (WHO, 2006) were preferentially selected, using those based on the National Center for Health Statistics international growth reference (Hamill et al., 1979) only for the 2006 or 2007 surveys and limited to within-country analyses. Sample weights were used as reported by DHS and MICS data sets.

In the case of DHS datasets, the Household Member Recode file was used, and variables HC70 (height for age standard deviation according to WHO), HC71 (weight for age standard deviation according to WHO), HC72 (weight for height standard deviation according to WHO), HV005 (household weight), HV270 (wealth index quintile), and HV140 (birth certificate / registered) selected. In the case of Ethiopia, whose report was published in 2006, the NCHS z-scores were used (HC5, HC8, HC11); in this dataset, the information on "birth certificate / registered" was reported in the variable SH20.

In the case of MICS, the following variables from the unit of analysis 'Mothers or primary caretakers of children under the age of five' were used: HAZ2 (height for age z-score WHO), WAZ2 (weight for age z-score WHO), WHZ2 (weight for height z-score WHO), FLAG (flag for anthropometric indicators), chweight (children's sample weight), windex5 (wealth index quintiles), BR1 (does [name] have a birth certificate?) and BR2 (has [name]'s birth been registered with the civil authorities?). A new variable (BR) was constructed that considered registered children with a birth certificate (BR1: both seen and not seen) and children with their birth registered (BR2: yes). In the case of Somalia, whose report was published in 2006, the variable BR2 was not present and the NCHS z-scores were used (HAZ, WAZ, WHZ). The same nutritional indices have been used for Côte d'Ivoire.

The analysis on the effect of age imprecision on undernutrition prevalence was performed using only the data from the MICS survey of Swaziland. The variables HL4 (sex), CAGE (age, months), AN3 (child's weight, kilograms), and AN4 (child's length or height, centimeters) were also included in the analysis.

Children who were flagged for out-of-range z-scores or invalid z-scores in any one of the three nutritional indicators have been excluded from the analysis. In MICS dataset the variable FLAG was used for this purpose while in the DHS the values defined as '999' or '9999' were used to select invalid data. As to the variables related to BR, cases showing 'don't know' or 'missing' labels were excluded from the analysis. Sample weight was applied using HV005 and chweight variables that represent the proportional part of the respective weights. This means that they have been normalized according to the specific group analyzed.

A total of thirty-seven sub-Saharan African countries have been analyzed (Table 2.1). Eritrea and Malawi have not been considered because no birth registration data whatsoever were available. Other countries (Angola, Botswana, Cape Verde, Comoros, Djibouti, Mauritius, Seychelles, South Africa, Sudan) were not considered because surveys, or malnutrition levels, or wealth quintiles details were not available. Madagascar was considered only for stunting prevalence.

Composition of the samples

DHS and MICS reports do not describe the composition of the sample used for nutritional analysis in terms of birth registration, i.e. what proportion of unregistered children was included in such sample. In order to quote such proportion, the total number of children under five years, the number of children examined for nutritional status, and the samples' composition in terms of birth registration were retrieved from the DHS and MICS datasets relative to 34 countries. Guinea-Bissau, Equatorial Guinea and Mauritania were not included because the data sets relative to the more recent surveys were not yet available.

Table 2.1 Data on nutritional status and birth registration in the thirty-seven sub-Saharan African countries considered in the present research

Country	Code	Stunting (%)	Underweight (%)	Wasting (%)	n_{NS}	BR rate (%)	n_{tot}	Survey
Benin	BEN	43·1	18·4	8·4	13 099	60·3	14 563	DHS, 2006*
Burkina Faso	BFA	34·6	25·7	15·5	6994	76·9	14 704	DHS, 2010
Burundi	BDI	57·7	28·8	5·8	3590	75·2	7600	DHS, 2010
Cameroon	CMR	32·5	14·6	5·6	5860	61·4	11 802	DHS, 2011
Central African Republic (The)	CAF	40·7	23·5	7·4	10 255	61·0	10 474	MICS, 2010
Chad	TCD	38·7	30·3	15·7	14 949	15·7	17 005	MICS, 2010
Congo (The)	COG	24·4	11·6	5·9	4591	90·8	8558	DHS, 2011–12
Côte d'Ivoire	CIV	34·0	20·2	6·9	8099	54·9	8604	MICS, 2006*
Democratic Republic of the Congo (The)	COD	43·4	24·2	8·5	10 662	28·0	11 093	MICS, 2010†
Equatorial Guinea	GNQ	26·2	5·6	3·1	1094	53·5	2932	DHS, 2011
Ethiopia	ETH	46·5	38·4	10·5	4586	6·6	10 831	DHS, 2005*
Gabon	GAB	16·5	6·0	3·3	3856	89·6	5952	DHS, 2012
Gambia (The)	GMB	23·4	17·4	9·5	11 425	52·5	11 637	MICS, 2010
Ghana	GHA	22·7	13·4	6·2	7381	62·5	7550	MICS, 2011
Guinea	GIN	31·2	18·0	9·6	3531	57·9	7073	DHS, 2012
Guinea-Bissau	GNB	32·2	18·1	5·8	12 354	24·1	12 767	MICS, 2010
Kenya	KEN	35·3	16·1	6·7	5470	60·0	5956	DHS, 2008–09‡
Lesotho	LSO	39·2	13·2	3·8	2086	45·1	4174	DHS, 2009
Liberia	LBR	39·4	19·2	7·5	5166	3·6	6028	DHS, 2007
Madagascar	MDG	50·1	–	–	5436	79·7	13 134	DHS, 2008–09‡
Mali	MLI	38·3	25·5	12·7	4857	84·3	10 748	DHS, 2012–13
Mauritania	MRT	29·7	24·4	13·9	8668	58·8	9278	MICS, 2011
Mozambique	MOZ	42·6	14·9	5·9	10 313	47·9	10 718	DHS, 2011
Namibia	NAM	29·0	16·6	7·5	4945	67·1	5461	DHS, 2006–7
Niger (The)	NER	43·9	36·4	18·0	5481	63·9	13 584	DHS, 2012
Nigeria	NGA	36·8	28·7	18·0	26 190	29·8	30 108	DHS, 2013
Rwanda	RWA	44·2	11·4	2·8	4356	63·2	8971	DHS, 2010
São Tomé and Príncipe	STP	29·3	13·1	10·5	1544	75·1	2101	DHS, 2008–09
Senegal	SEN	26·5	17·7	10·1	3761	74·6	12 226	DHS, 2010–11
Sierra Leone	SLE	44·4	21·7	8·5	7952	78·0	8598	MICS, 2010
Somalia	SOM	37·8	35·6	11·0	5424	3·0	6305	MICS, 2006§
Swaziland	SWZ	30·9	5·8	0·8	2560	49·5	2647	MICS, 2010
Togo	TGO	29·7	16·6	4·8	4668	77·9	4746	MICS, 2010
Uganda	UGA	33·4	13·8	4·7	2350	29·9	8361	DHS, 2011
United Republic of Tanzania (The)	TZA	42·0	15·8	4·8	7491	16·3	8081	DHS, 2010
Zambia	ZMB	45·4	14·6	5·2	5602	14·0	6341	DHS, 2007
Zimbabwe	ZWE	32·0	9·7	3·0	5260	48·8	5912	DHS, 2010–11

Code, three-letter code for each country provided in ISO 3166: n_{NS}, sample size used for nutritional assessment (as retrieved from reports (nutritional status)); BR, birth registration; n_{TOT}, total sample size (retrieved from reports (birth registration)); DHS, Demographic and Health Survey (http://www.dhsprogram.com/data/available-datasets.cfm); MICS, Multiple Indicator Cluster Survey (http://childinfo.org/mics_available.html).
*More recent reports have been published, but they lack some necessary data (BR or wealth quintiles).
†Total sample size retrieved from data set.
‡More recent reports have been published for sub-regions: South Madagascar and Nyanza Province of Kenya.
§More recent reports, related to new Somaliland and Somalia (Northeast Zone), have been published, but they lack data on BR and nutritional status

The difference between percentages of BR in the total sample and in the sample used for nutritional analysis has been assessed using a permutation test. For each of the 170 combinations of country/wealth class, we have calculated the difference between BR rates and the corresponding observed mean on the 170 differences. We have repeated the calculation 10000 times, where the labels 'total' and 'nutrition' sample have been randomly permuted. The obtained 10000 mean values represent the distribution of the mean under the hypothesis of no differences. Hence, we have calculated the probability of observing a mean difference larger than the observed one.

Effects of selection bias due to birth registration on undernutrition prevalence

The analysis on the relationship between BR and malnutrition or wealth status was performed in a subset of 33 countries whose indexes of malnutrition were based on the WHO Child Growth Standards adopted in 2006, because the corresponding nutritional values are not directly comparable to those based on the previous NCHS/CDC/WHO references (Yang and de Onis, 2008) used for reports on Ethiopia, Côte d'Ivoire, and Somalia. Guinea was also excluded because the report does not show the BR rate for wealth quintile.

The database assembled comprises seven variables (detailed for the total sample and wealth quintiles), retrieved from the open access DHS and MICS reports: prevalence of stunting, underweight, and wasting; size of the sample used for nutritional assessment ('nutritional subsample'); prevalence of children registered at birth; size of the sample used for evaluating birth registration rate; survey (MICS or DHS, year). This database is also freely available at the Cagliari University institutional repository (http://veprints.unica.it/1119/).

The relationship between BR and undernutrition prevalence was explored using logistic regression, i.e. a linear regression between the undernutrition indicator, considered in the logit scale where logit(Y)=log(Y/(1-Y), and the explanatory variables: BR and country. The variable Y represents the observed proportion of undernutrition in each wealth quintile.

In more detail, *B* and *C* represent BR and country, respectively, and B.*C* indicates the interaction between BR and country; the model can be represented as follows:

$$\text{logit}(Y)=ß_0+ß_B B+ ß_C C+ ß_{B.C} B.C,$$

where we assumed that there exists a common (to all countries) undernutrition mean $ß_0$ and slope $ß_B$, plus a country specific mean and slope represented by parameters $ß_C$ and $ß_{B.C}$.

The goodness of fit of the model has been assessed by looking at the residuals and Cook's distances, in order to exclude the presence of outliers. The significance level has been assessed using the χ^2 test for the residual deviance. The analysis was repeated for each nutritional indicator (HAZ, WAZ, WHZ) separately. Considering the heterogeneity of the countries, the chosen regression model provided satisfactory results either in terms of interpretation and precision.

Further, in each wealth class of twenty-eight countries (excluding those with BR≤ 10% or ≥90%, we tested the hypothesis that the undernutrition proportion has the same mean in registered and unregistered children against the hypothesis that it is higher in unregistered ones. For this purpose, the data sets 'Household Member Recode file' (DHS) and 'Mothers or primary caretakers of children under the age of five' (MICS) were used, selecting the variables: HAZ, WAZ, WHZ; wealth index quintile; birth certification/registration; sampling weights.

The Student's t test with Welch correction was used and the multiplicity of tests was accounted for using the Benjamini–Hochberg (1995) procedure. It consists of multiplying the set of ordered p-values,

$p_{(1)}<.....<p_{(i)}<.....<p_{(m)}$, where m=140 tests, by the set of increasing sequence m/i, that is m, $m/2$, $m/3$, ..., 1. Such new or adjusted p-values, $mp_{(1)}$, …, $m/ip_{(i)}$ are on the False Discovery Rate (*FDR*) scale. This scale is very useful because it is informative of the amount of FDR that we committed to when rejecting all hypotheses with an adjusted p-value lower than a chosen α (e.g. α=0.05). Such FDR is no larger than α in mean.

Effects of age bias and information error on undernutrition prevalence

The effect of age misreporting (information bias and information error) on the estimates of stunting and underweight was evaluated using the data from Swaziland, as an example. The case study of Swaziland was chosen because of its relatively small sample size, that is easier to handle and check for quality, and that can furnish a more reliable variance upper bound.

We evaluated the effect of 1, 3, and 6 months of magnitude error in age, both in excess and in defect. Larger errors were considered improbable on the basis of pertinent literature (Alderman, 2000). Only children 24-60 months of age were considered in the analysis because an error of 6 months was considered less probable in children with a lower age, and because stunting is measured differently in children 0-24 months (length for age) than in older ones (height for age).

The effect of age bias on undernutrition estimates was considered equal to the prevalence of children with a stature (or weight) between the -2 SD stature (or weight) value of their true age and the -2 SD stature (or weight) value of a defined incorrect age. In fact, exemplifying, a 30-month-old male with a stature of 84.9 cm is stunted because such value is lower than the -2SD cut off (85.1 cm). However, if he is erroneously considered to be 29 months old, his stature would be within the normal range, as the cut off for stunting at this age is 84.5 cm. Similarly, all children aged 30 months with a stature comprised between 84.5 and 85.1 cm would be considered normal, underestimating their stunting, if their age were systematically biased of one month in defect.

In order to evaluate random error, the differential effect between excess and defect in assigning age on undernutrition evaluation has been empirically evaluated by looking at the 95% probability intervals on the distribution of the differences in undernutrition prevalence calculated with an incorrect age and with the exact age. The intervals have been calculated separately for each combination of HAZ/WAZ with sex and the order of magnitude (1, 3 and 6 months). They estimate the distribution of the compensated error on undernutrition prevalence and are informative about the hypothesis of perfect compensation between deviations in excess and in defect. Informally, such hypothesis is acceptable if the zero value is included into the interval. From a more formal perspective, the hypothesis of compensation has been evaluated using a Student's t-test between the absolute mean of increasing and decreasing in the undernutrition proportion. All statistical analyses were performed using the R program (http://www.R-project.org).

Results

Composition of the samples

Different sampling designs were detected among countries (Figure 2.1). In some cases, the number of children selected for anthropometry was half or less of the total number of surveyed children (38–52 %), while in others it approached the total number (90–99 %; Figure 2.1(a)). Heterogeneities were also present in the proportion of registered children included in the nutritional subsample, which ranged from less than 10 % to 99.7 % (Figure 2.1(b)). In general, the proportion of registered children was greater in countries with higher BR and in higher wealth classes. A slight but highly significant tendency ($P<0{\cdot}0001$; mean difference=0.5 %) towards an over-representation of registered children in the nutritional subsample with respect to the total sample was observed (Figure 2.2).

Effects of selection bias due to birth registration on undernutrition prevalence

A negative relationship between BR and undernutrition prevalence was observed (Figure 2.3). The relationship was also present within countries, where lower wealth quintiles (represented by dots '1') are mostly positioned in the left and upper section of the plots, corresponding to lower BR rates and higher malnutrition prevalence.

Stunting and underweight showed stronger negative associations with BR than did wasting. This association was shared by all countries irrespective of wealth class and thus can be regarded as a general negative association. The relationship was further supported by the logistic regression results, where all of the explanatory variables (country, BR and their interaction) were highly significant ($P<0\cdot0001$; Table 2.2 and Table S1, the last one available, on-line, as supplementary material at the follow address: http://dx.doi.org/10.1017/S136898001500333X).

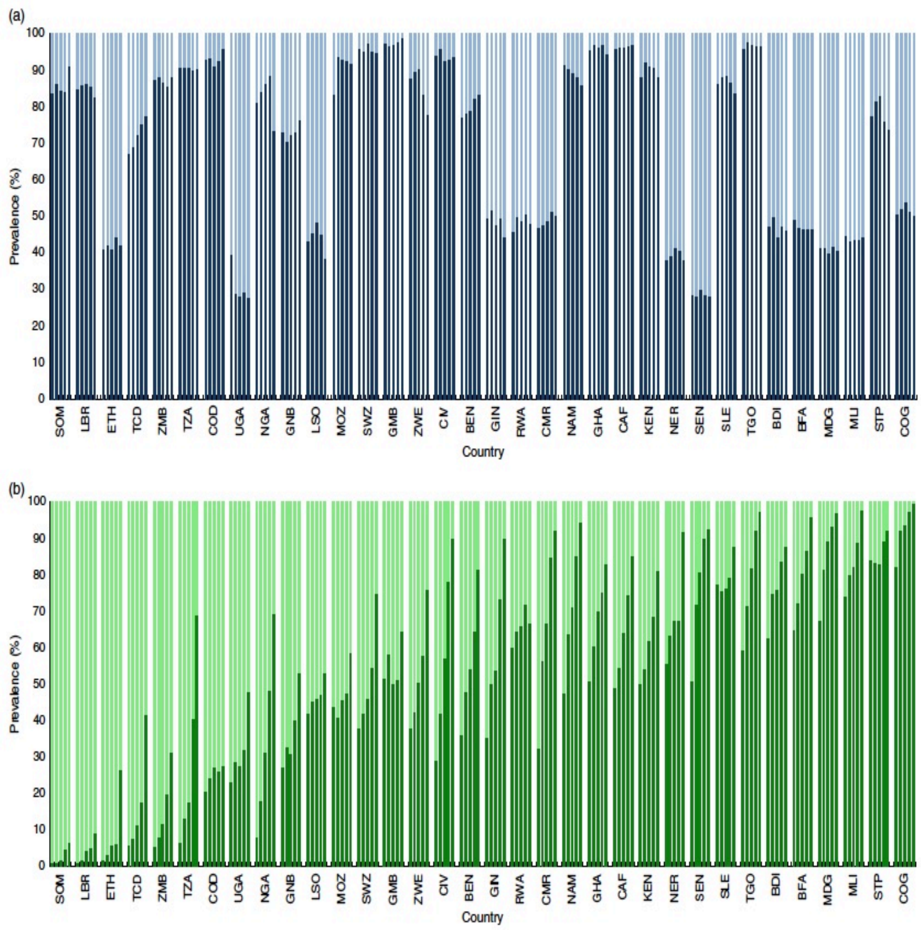


Figure 2.1 Sample composition: (a) prevalence of children analysed for nutritional assessment (nutritional subsample;) in the total sample (total bar length) and (b) prevalence of registered children ( ) in the nutritional subsample (total bar length); data from Multiple Indicator Cluster Surveys and Demographic and Health Surveys in 34 sub-Saharan African countries (country's acronyms are provided in Table 2.1). Each country is represented by five bars corresponding to wealth quintiles

The association between BR and stunting or underweight was significantly less accentuated in some countries (e.g. stunting: GAB, MDG; underweight: CAF, TCD), although still negative ($P<0{\cdot}001$; Table S1). Wasting showed a greater homogeneity of results among countries (Table S1).

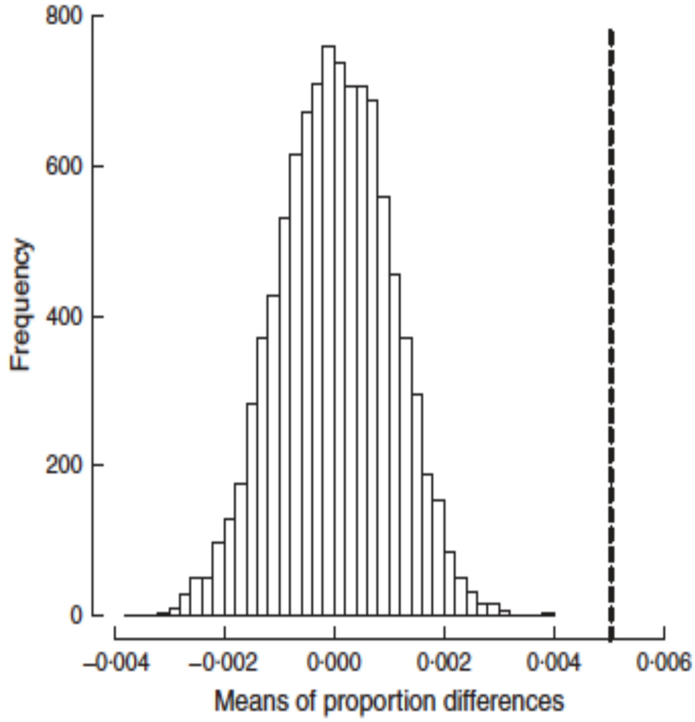


Figure 2.2 Distribution of the means of proportion differences in 10000 permutations of the total with the nutritional subsample along with the observed value (vertical dotted line), indicating the significant over-representation of registered children (0·5%) in the nutritional subsamples

Registered children generally presented a better nutritional status than unregistered ones, with significantly higher HAZ mean values in forty cases out of 140 comparisons (28.6 %; Figure 2.4(a)), higher WAZ mean values in fifty-one cases (36.4 %; Figure 2.4(b)) and higher WHZ mean values in thirty-eight cases (27.1 %; Figure 2.4(c)).

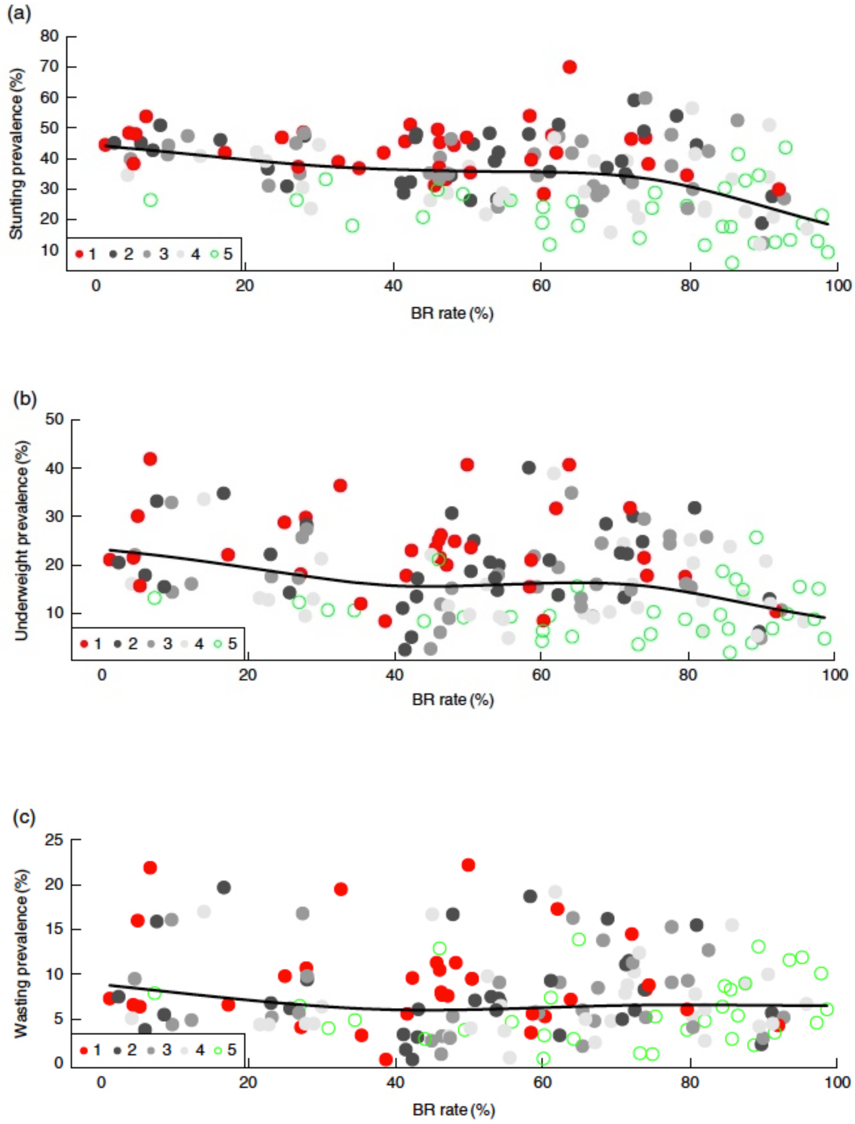
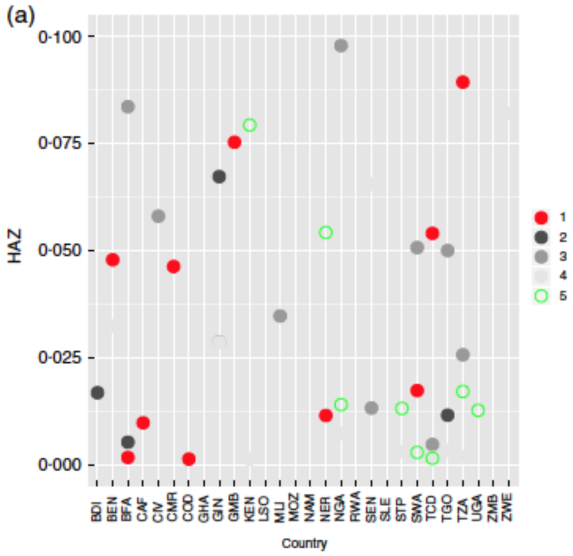


Figure 2.3 The relationship between birth registration (BR) rate and malnutrition prevalence: (a) stunting; (b) underweight; and (c) wasting, according to wealth quintile (where 1 represents lower wealth quintiles, 5 represents higher wealth quintiles, and 2, 3 and 4 represent intermediate quintiles); data from MICS and DHS in thirty-three sub-Saharan African countries

Table 2.2 Logistic regression between birth registration and undernutrition rates; data from Multiple Indicator Cluster Surveys and Demographic and Health Surveys in 33 sub-Saharan African countries

	Single effect		Cumulative effect		
	df	Resid. dev.	df	Resid. dev.	*P* value
Stunting					
BR	1	0·331	163	2·007	$<2·2\times10^{-16}$***
Country	32	1·583	131	0·424	$<2·2\times10^{-16}$***
BR × country	32	0·209	99	0·216	$2·71\times10^{-8}$***
Underweight					
BR	1	0·095	158	1·186	$<2·2\times10^{-16}$***
Country	31	1·054	127	0·133	$<2·2\times10^{-16}$***
BR × country	31	0·058	96	0·075	$1·67\times10^{-5}$***
Wasting					
BR	1	0·003	158	0·352	$6·81\times10^{-6}$***
Country	31	0·325	127	0·027	$<2·2\times10^{-16}$***
BR × country	31	0·012	96	0·014	$2·55\times10^{-6}$***

Resid. dev., residual deviance; BR, birth registration rate (*B*); BR × country, interaction between BR rate and country (*B* × *C*).
****P*<0·001.



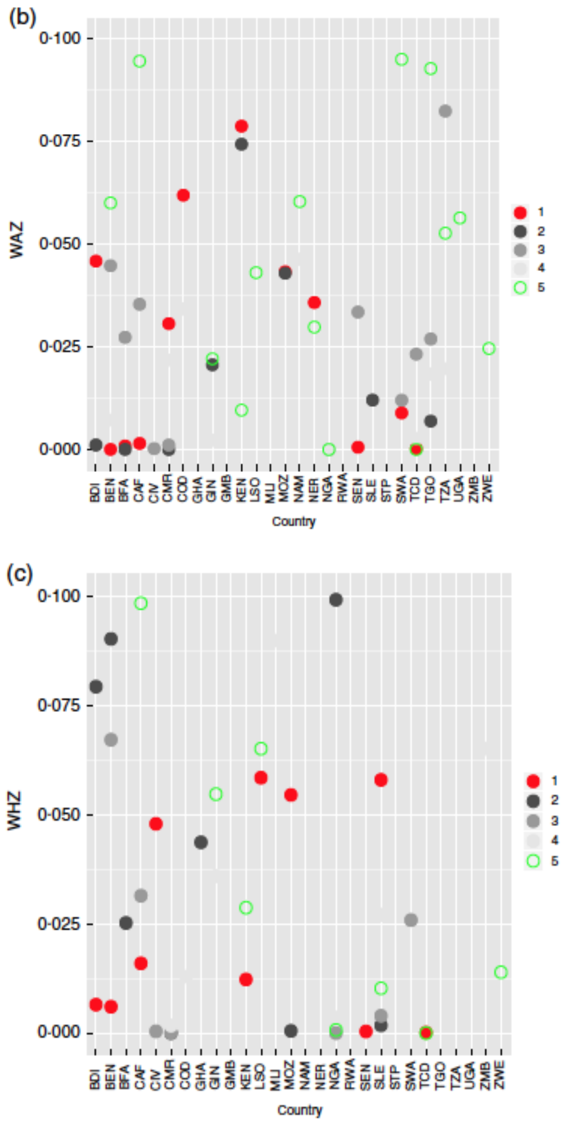


Figure 2.4 Values of (a) height-for-age Z-score (HAZ), (b) weight-for-age Z-score (WAZ) and (c) weight-for height Z-score (WHZ) in registered v. not registered children within wealth quintiles (where 1 represents lower wealth quintiles, 5 represents higher wealth quintiles, and 2, 3 and 4 represent intermediate quintiles); data from MICS and DHS in 28 sub-Saharan African countries (country's acronyms are provided in Table 2.1). Dots represent significant comparisons ($P<0{\cdot}1$)

Effects of age bias and information error on undernutrition prevalence

Figures 2.5 and 2.6 show the effect of age bias and random error in the case of Swaziland. The error in undernutrition prevalence increased with the increase of systematic error of age (Figure 2.5) and was greater in younger children (Figure 2.7).

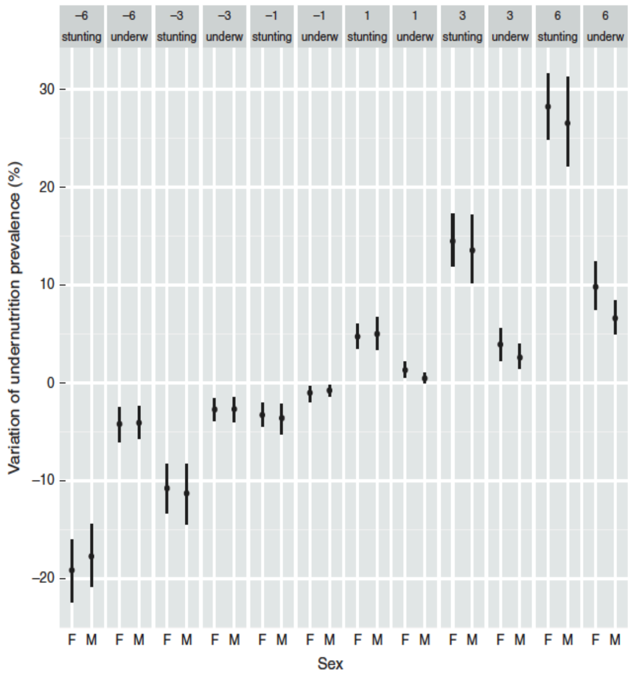


Figure 2.5 The effect of age bias on stunting and underweight prevalence in the case of Swaziland children aged between 24 and 59 months. Error bars represent the 95% bootstrap confidence interval of the variation (underw, underweight; –1/1, 1 month underaged/ over-aged; –3/3, 3 months under-aged/over-aged; –6/6, 6 months under-aged/over-aged; F, females; M, males)

The shift was more pronounced in stunting than in underweight and in 'over-aged' than in 'under-aged' children, but similar in males and females. The difference in undernutrition prevalence ranged from 0.44 % (underweight, +1 month, males) to 28.2% (stunting, +6 months, females) as it can be observed in Table 2.3. The effect was significant in all cases, with the exception of 1-month deviation in underweight (both sexes). The random error caused an overestimate of undernutrition prevalence, because of the greater error due to overestimation of age (Figure 2.6).

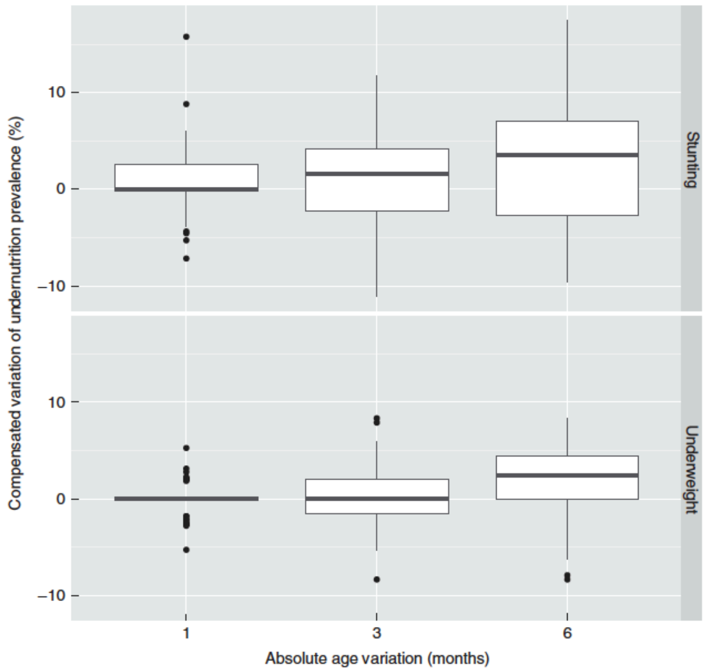


Figure 2.6 Box-and-whisker plot showing the effect of random error of age on stunting and underweight prevalence in the case of Swaziland children aged between 24 and 59 months. The bottom and top edge of the box represent the first and third quartiles (interquartile range); the line within the box represents the median; the ends of the bottom and top whiskers represent the minimum and maximum values in the absence of dots, otherwise they indicate the range of non-outliers observations; and the dots represent outliers (1, ±1 month; 3, ±3 months; 6, ±6 months)

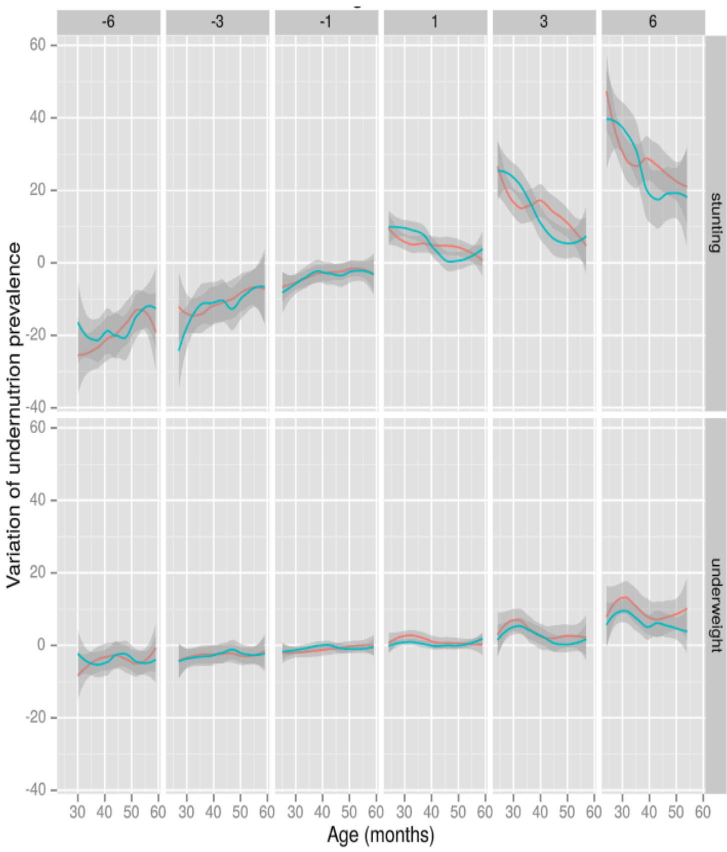


Figure 2.7 Variation of stunting and underweight prevalences on males (blu lines) and females (red lines), in different ages and for different systematic error of age (± 1 month, ± 3 months, ± 6 months)

As for systematic error, the effect increased with the increase of age error, becoming significant in the case of a ±6 months deviation, when it caused an overestimate of stunting (2.7%; P= 0.005) and underweight (1.8%; P = 0.002). Data are reported in Table 2.4.

<u>Discussion</u>

The 2011 MICS conducted in the Northeast Zone of Somalia (UNICEF, 2014b) does not give information on child undernutrition because 'in the absence of birth registration and other services relating to vital statistics, it is extremely difficult to get correct age related data'. It is an uncommon choice that a national health survey omits such relevant information.

Table 2.3 Effects of age bias in the actual case of Swaziland children for stunting and underweight, and males and females

		month shift	prevalence shift (mean)	P value	
stunting	females	+ 1 m	4.718	0.000	***
		+ 3 m	14.460	0.000	***
		+ 6 m	28.214	0.000	***
		-1m	-3.298	0.000	***
		-3 m	-10.781	0.000	***
		-6 m	-19.168	0.000	***
	males	+ 1 m	4.978	0.000	***
		+ 3 m	13.525	0.000	***
		+ 6 m	26.524	0.000	***
		-1m	-3.616	4e-05	***
		-3 m	-11.307	0.000	***
		-6 m	-17.754	0.000	***
underweight	females	+ 1 m	1.286	0.002	**
		+ 3 m	3.909	6e-05	***
		+ 6 m	9.798	0.000	***
		-1m	-1.040	0.006	**
		-3 m	-2.740	4e-05	***
		-6 m	-4.224	3e-05	***
	males	+ 1 m	0.439	0.044	*
		+ 3 m	2.576	0.000	***
		+ 6 m	6.588	0.000	***
		-1m	-0.798	0.006	**
		-3 m	-2.698	0.000	***
		-6 m	-4.096	3e-05	***

Legend: (m= month; * = p < 0.05; ** = p < 0.01; *** = *p* < 0.001)

Table 2.4 Effects of random error in age in the actual case of Swaziland children

	month shift	prevalence shift (mean)	P value	
HAZ	± 1 m	0.765	0.057	
	± 3 m	0.846	0.177	
	± 6 m	2.745	0.005	**
WAZ	± 1 m	-0.016	0.932	
	± 3 m	0.181	0.626	
	± 6 m	1.770	0.002	**

Legend:HAZ = height-for-age Z-scores; WAZ = weight-for-age Z-scores; m = month; * = p < 0.05; ** = p < 0.01; *** = *p* < 0.001

However, insufficient or unreliable information about a child's age is a concrete obstacle to nutritional assessment, because the indicators stunting and underweight cannot be accurately calculated without such data. Unsurprisingly, the problem has emerged in a region of Somalia, i.e. a country with one of the lowest rates of registered children (Table 2.1). However, a similar problem could occur in other countries too, where the coverage of BR is still incomplete, even if established structures for vital data collection are functioning. In those regions, undernutrition prevalence can be affected by different errors: a selection bias towards children with a valid date of birth, such as registered children, and information errors or information biases, that more probably affect estimates based on unregistered children.

Effects of selection bias due to birth registration on undernutrition prevalence

Children whose births are registered have better nutritional status than unregistered ones and this is apparent from the comparison among countries, among wealth quintiles within countries and between groups within quintiles. The negative relationship between BR and child nutritional status observed in the present research among sub-Saharan countries has not been previously analysed in detail. However, a similar pattern was suggested by UNICEF (2005) when stating that 'children receiving adequate nutrition are more likely to be registered'.

The negative relationship is also present within countries, where wealth status is positively associated with BR (UNICEF, 2013a) and nutritional status (Barros et al., 2010), as can be seen in Figure 2.3. Furthermore, within each wealth quintile registered children have better nutritional status than unregistered ones. This difference can be related to the wealth variability among households within the same quintile or to the residual variability not accounted for by the wealth index that can appear when other socio-economic factors are held constant. In particular, cultural differences, such as religious or ethnic background, can produce disparities in BR rates (Barros et al., 2010; UNICEF, 2013a) and also in nutritional status (Brockerhoff and Hewett, 2000; Beiersmann et al., 2013; Lawson et al., 2014). Mothers' education may also have an effect, since it influences in a similar way behaviors related to feeding, child-care practices and health-service utilization (Barros et al., 2010; Ssewanyana and Kasire, 2012a). In fact, children whose mothers have received at least primary schooling have higher BR rates (UNICEF, 2013a) and better health (Barros et al., 2010; Gakidou et al., 2010; Ssewanyana and Kasire, 2012a; Beirsmann et al., 2013; de Onis et al., 2013) than those with uneducated mothers.

An additional explanation for the better nutritional status of registered children is the possibility that their age was declared lower than their true age. When considered for nutritional assessment, these children are compared with younger ones – with smaller body dimensions – and their nutritional status appears better than it actually is. This kind of information bias has been observed in some countries where people have an advantage in registering their newborns close to their birthday (Oshaug et al., 1994; UNICEF, 2005; UNICEF, 2013b).

The better nutritional status of registered children could cause the underestimation of undernutrition if they were preferentially included in nutritional surveys. This is a likely possibility, considering the need for exact age knowledge for the assessment of nutritional status. Even if DHS and MICS sampling designs are directed to produce statistically reliable estimates of most indicators at the national level, and children are not selected based on the availability of birth records, those without full birth date are excluded from nutritional analysis, as detailed within reports. In fact, the results of the present research have shown a significant selection bias, with registered children slightly more represented in the nutritional subsamples.

Effects of age bias and information error on undernutrition prevalence

Comparing reports from two different Malian regions, Hatløy (1999) showed that age heaping was much lower in the survey where 55 % of the children had a birth certificate, compared with where birth certification was less than 10 %. In general, when nutritional status is assessed in unregistered children, it is more probable to rely on an incorrect child's age due to information bias and information error.

Information bias can occur because of the tendency to overestimate the age of a well-nourished child and underestimate that of a malnourished one, especially if not wasted (Bairagi et al., 1991; Oshaug et al., 1994). An upward age heaping has been effectively observed in Somalia and Kenya (Bairagi and Langsten, 2008), whereas a tendency to downward heaping was found in Bangladesh (Bairagi and Ashan, 1998) and Burundi (Bairagi and Langsten, 2008).

In sub-Saharan Africa, age misreporting is quite a common phenomenon (Hatløy, 1999; Bairagi and Langsten, 2008). According to Bairagi and Langsten, 2008, about 20% of Kenyan children surveyed in 2007 had only their year of birth, and no month imputed; nevertheless, an age in months was attributed to these children. Further, during recent fieldwork on child nutrition in Uganda and Tanzania, we have found insufficient or inconsistent data on age in more than 40% of the 960 examined children (Comandini et al, 2017).

Both information bias and error have an effect on undernutrition prevalence estimates. Using data from Swaziland children, we have shown that age bias has a more pronounced effect in younger children (as similarly observed by Bairagi, 1986 and Gorstein 1989), in stunting than in underweight values (as in Bairagi, 1986 and Oshaug et al., 1994) and in 'over-aged' than in 'under-aged' children (also in Oshaug et al. 1994). The magnitude of error ranged between 0.4 % and 28.2 %, according to the nutritional indicator and age bias. Similar or higher errors have been observed elsewhere (Bairagi, 1986; Bairagi et al., 1987; Gorstein, 1989;

Oshaug et al. 1994), with a maximum underestimation of stunting prevalence by about half in 1-year-old children with a 1 month age reduction (Gorstein, 1989).

Under the assumption of equal probability of deviations in excess and in deficit, random error has no effect on the mean age because the deviations compensate for each other. The corresponding effect on undernutrition prevalence, however, is not necessarily null (Figure 2.8). The magnitude of such an effect depends on the child's age and degree of undernutrition. In the case of Swaziland, random error caused an overestimate of undernutrition prevalence of up to 2.7%.

In short, non-sampling error probably produces the underestimate of undernutrition prevalence. In fact, information error has a smaller effect than information bias and age is more likely underestimated in undernourished children.

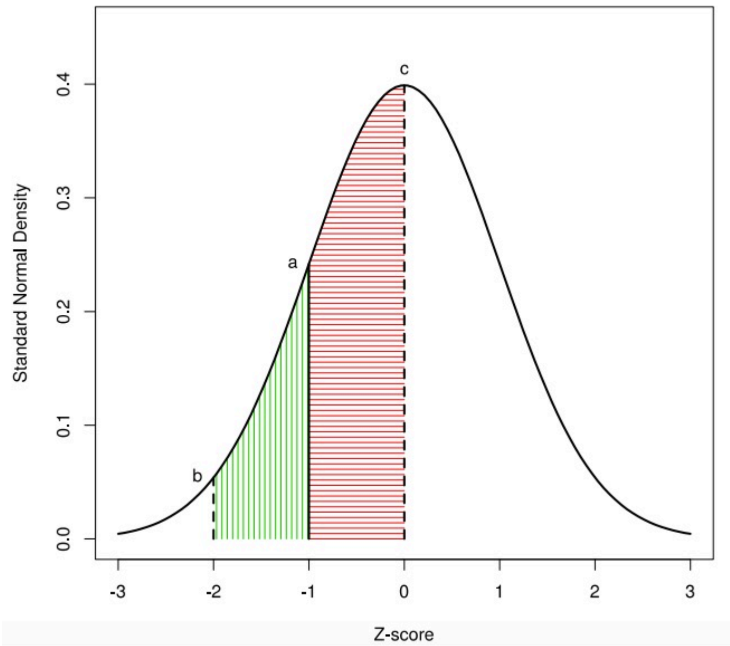


Figure 2.8 The effect of random errors on undernutrition prevalence is not null. Red and green areas due to equal age underestimation and age overestimation are different.

Actual situation due to sample composition

Sampling differences observed in the sub-Saharan African surveys, in the proportion of children analysed for assessing nutritional status (Figure 2.1(a)) and the composition in terms of registered and unregistered children (Figure 2.1(b)), may have an influence on the accuracy and reliability of undernutrition estimates. The different proportions of registered children (Figure 2.1(b)) do not appear associated with geographic location (West and Middle v. South and East Africa), socio-economic level (low v. middle income), type of survey (DHS v. MICS), or with the sampling design shown in Figure 2.1(a).

Countries represented by samples with a greater prevalence of registered children have a higher risk of undernutrition underestimation, while errors due to age misreporting are more likely to occur in countries with a high prevalence of unregistered children, particularly Somalia, Liberia and Ethiopia. When this latter source of error is associated with a low proportion of children selected for nutritional evaluation, as happens for example in Ethiopia, the imprecision of undernutrition estimates increases. Vice versa, estimates are more reliable in countries, for example Sierra Leone and Togo, with a greater coverage of children included in nutritional analysis and of registered children in the nutritional subsample.

Conclusion

Based on MICS and DHS data from sub-Saharan Africa, we have shown that a selection bias favoring registered children and, more generally, children with a 'valid date of birth – month and year' is present and can lead to underestimate undernutrition prevalence. Furthermore, unregistered children are more likely prone to information bias and error, whose probable effect is, again, the underestimation of undernutrition. Errors affect sub-Saharan African countries differently, due to the differences in sampling design and BR rates existing among them.

DHS and MICS remain the most valuable source of data on child health in low- and middle-income countries and the best tool for national and global decision making. However, these results indicate that nutritional estimates can be imprecise and the situation can be worse than shown. In particular, stunting is the indicator most affected by age error. Hence, although it is highly informative on child nutritional status (de Onis et al., 2013), it is less reliable in situations where children's ages are imprecise. In these cases, age-independent indices of nutritional status, such as weight-for-height (as suggested by WHO for refugee situations) (WHO, 2008) or mid upper-arm circumference with a cut-off point, should be used, even if they describe only particular facets of undernutrition. Further, as suggested by FAO, 2008, community events calendars, such as those recently applied in the 2013–14 DHS in Togo and in the 2011 MICS in Somaliland, should be broadly used to collect more accurate information on child age. Moreover, nutritional surveys should indicate the methods used to assess child age.

In summary, considering the key role of nutritional indicators in health programs and the central role of nutrition to sustainable development (IFPRI, 2014), we stress the importance of national and global efforts to continue promoting BR. In fact, no alternative biological tool exists to assess age with enough precision to be used for nutritional assessment and which is not itself influenced by nutritional status. The global challenge for improving BR, besides being central to inequalities reduction in terms of access to health, education and housing, is also relevant to strengthen the quality of epidemiological data on nutritional status. Programmatic actions applied to fulfil this goal (free registration of birth, better communication, use of mobile and digital technology, collaboration among sociopolitical programs and the health sector) have started to yield results and need to be continued until achieving universal registration of children immediately after birth (UNICEF, WHO, The World Bank, 2013).

2.3 NUTRITIONAL EVALUATION OF UNDOCUMENTED CHILDREN: A NEGLETCTED HEALTH ISSUE AFFECTING THE MOST FRAGILE PEOPLE

The precise knowledge of age is necessary for assessing a child's nutritional status, in particular for calculating the most common indicators of undernutrition: stunting and underweight (WHO, 1995). However, in low- and middle-income countries, especially in sub-Saharan Africa and South-East Asia, where undernutrition is a public health issue, information on age is frequently imprecise or absent, mainly due to the low practice of registering children at birth (UNICEF, 2013a). The unknown or unreliable age is also a common condition among the huge number of migrants and refugees who are coming to Europe (WHO, 2016). Such people include minors, who have experienced stress and trauma during their long journeys and need adequate health care. The 'scandal of invisibility' (Horton, 2007), which affects more than 230 millions of children under five worldwide (UNICEF, 2013b), has been widely debated in relation to social, political, ethical, and also epidemiological implications, but rarely in relation to nutritional status. However, the consequences of insufficient or imprecise age data on stunting and underweight estimates are substantial. In a recent article, we have calculated that a 6-month bias can produce an error up to 28% in the stunting prevalence of children below 5 years of age from Swaziland (Comandini et al., 2017). The random error (equal probability of over- or underestimating age), even without affecting mean age because deviations compensate each other, can have an effect on undernutrition prevalence (Comandini et al., 2017).

This research highlights the magnitude of age error in some real contexts, especially in students of 3 Ugandan schools. Moreover, the effects of such errors on undernutrition estimates in a broad range of hypothetical situations are analyzed, and possible compensative strategies that could be used in public health are discussed.

Methods

Magnitude of age errors in real contexts

In a recent nutritional study on 1056 Ugandan children (508 males; 548 females; 3–16 years), we collected age data in different years (2012, 2014, 2015) and from various sources (parents, teachers, nurses, school or social workers, registers).

Effects of age error on malnutrition prevalence

We have calculated the effect of age bias and random error on stunting and underweight prevalence, and showed an overview of different scenarios of age error (Figure 2.9). Calculations of z-scores are based on WHO reference height and weight data (http://www. who.int/childgrowth/en/). As an example, we have considered a hypothetical population of male children aged between 5 and 10 years, with height-for-age Z-scores = -2 and a population mean zscore = -0.5 (Figure 2.9).

Moreover, a software has been created to be used freely (https://stefano-cabras.shinyapps.io/ageimperrapp/) in order to detect the effect of age bias on undernutrition prevalence in different situations
For different nutritional indicators and samples characteristics, in males and females, the effect of age bias on undernutrition prevalence can be calculated using the free software, and all information about the mathematical models used are reported in:
https://stefano-cabras.shinyapps.io/ageimperrapp/.

Results

Magnitude of age errors in real contexts

Information on age was available only for 843 children (79.8%). In 514 cases (61%) the complete date of birth (day, month, year) was known, while in 329 cases (39%) only the year of birth or the child's age in years was given. In these latter cases, more frequent in schools from poor settings and orphanages, we assigned the date of birth as July 1st (middle of the year).

For the 843 children with some information on age, we had two (202 children, 24.0%), three (24 children, 2.8%) or more data replicates (9 children, 1.1%). Within these 235 cases, the percentage of children with the same and complete date of birth in different sources was equal to 6.0% (14 children), indicating that uncertainty can also affect children with apparently reliable information on age. The gap between ages from two different sources was lower or equal to 6 months in 66 children (28.3%). The mean range of age was 7.5 (±8.8) months, and the maximum was 3 years and 3 months.

Effects of age error on malnutrition prevalence

Both bias and random error can produce a variation in the prevalence of malnutrition. Such effect decreases with child's age. Age bias produces a noticeable variation, in both cases of systematic over-age (right red areas in Figure 2.9) or systematic under-age (left green areas in Figure 2.9). A random shift of age (plus and less, i.e. equally probable over and underestimate of age) causes a lower change in malnutrition prevalence, perceivable in Figure 2.9 as the difference between green left and red right areas. For example, a bias of 10 months in excess produces an overestimate of stunting prevalence ranging from 12% (within 10 year children) to 22% (6 years), while a random error produces an overestimate of stunting ranging between 6% (10 years) and 14% (6 years).

<u>Discussion</u>

In this study based on the analysis of age data collected from different sources we have showed that errors can be meaningful and can cause significant variations in the malnutrition prevalence. Data repetitions on age are rarely available in nutritional studies, but in some cases the analysis of age-heaping has been used to estimate age misreporting.

Age-heaping has been observed in many sub-Saharan African countries, with a high frequency of adults' ages ending in 0 and 5 (Rutstein and Bicego, 1990) and of children aged at a complete year and at half a year (e.g. 7 years or 7 years and 6 months), (Bairagi and Langsten, 2008) or born on particular days of the month (Oshaug et al., 1994). Evidence of age heaping was also observed in a sample of 353 sub-Saharan African adults and minors seeking asylum in Sardinia (Italy), where 32.9% of subjects were born on the first day of the year (unpublished data). Interestingly, in our study we have detected a significant imprecision of age, but no age-heaping, suggesting that different sources of error can affect age data.

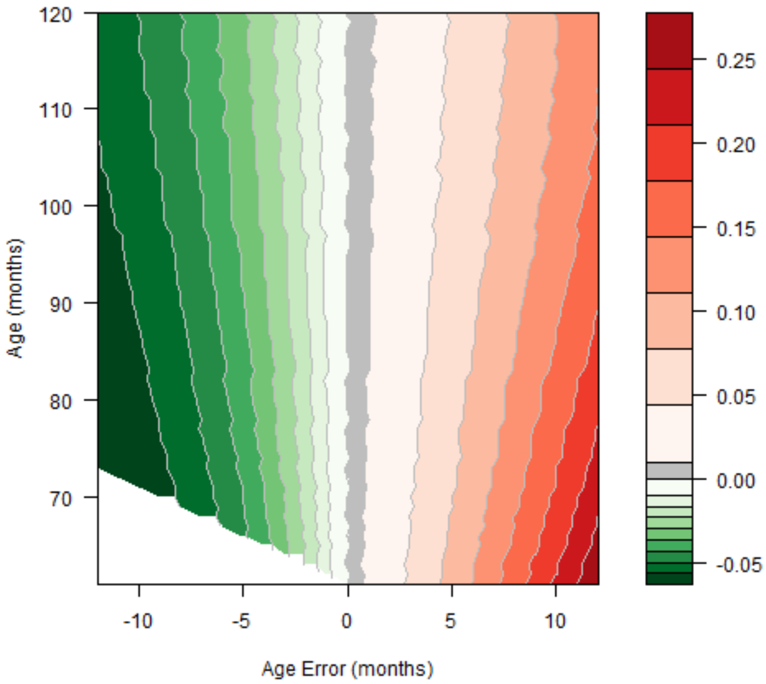


Figure 2.9 Effect of age bias and random error on stunting prevalence. Right areas correspond to systematic over-age; left areas to systematic under-age; for each hypothetical shift of age (plus and less, i.e. equally probable over and underestimate of age), the difference between the right and left areas corresponds to random error in malnutrition prevalence. The vertical bar on the right indicates the error in stunting prevalence

Methods for assessing nutritional status not requiring information on age, such as the weight-for-height (WHZ) index of wasting, or middle upper arm circumference, are suitable and are informative, but more appropriate to detect severe acute conditions (http://www.who.int/nutrition/topics/severe_malnutrition/en/). Moreover, international standards are only available for children up to 5 years (http://www.who.int/childgrowth/en/). Further, WHZ is unable to recognize stunted children who regained weight and has demonstrated weakness in very tall or very short children (Cole, 1985). Regrettably, accurate techniques for assessing age do not exist (Cole, 2015; Rinaldi, 2016). The use of physical maturation is imperfect and can produce high misclassification rates (Cole, 2015). Furthermore, skeletal, dental, or other developmental markers are influenced by nutritional status (and in fact used to evaluate it), hence their use for assessing both age and nutritional status lead to a vicious circle. According to Cole (2015), there is a need for alternative methods using extra information from socio-political approaches in order to establish a multi-disciplinary-'holistic'-process for age assessment, which could be adopted in all cases of unknown or undeclared age. In spite of the already discussed limitations, the analysis of nutritional status could give additive information. For example, wasted children (low WHZ) with normal or high weight-for-age Z scores could have had their age underestimated.

Beyond a shadow of a doubt, the more effective way to overcome age imprecision is to strengthen global and national efforts for improving the efficiency of civil systems and for raising awareness on the importance to register all children immediately after birth.

This first step for building a right-based system could contribute to removing socioeconomic and health inequalities—not letting down the most fragile people.

3. ASSESSMENT OF NUTRITIONAL STATUS[1]

3.1 INTRODUCTION

The assessment of a proper child's growth involves the measurement of child's weight and height/length and the comparison of the data collected with growth standards (WHO, 1995). Correct measurements and data interpretation are essential to distinguish among normal or deviate growth (WHO, 2008). In countries where child malnutrition is an important issue, the correct assessment of a child nutritional status allows specific health intervention including actions to address the causes of poor growth. Moreover, the monitoring children's growth permits an evaluation of their health status.

Since the late 1970s, the growth references recommended (WHO, 1995) for international use were those of the National Centre for Health Statistics/World health Organization (NCHS/WHO; http://www.cdc.gov/growthcharts/cdc_charts.htm) (Hamill, 1979). However, although they were well statistically robust, they resulted to be difficult to compare with others countries with different nutritional and health habits (de Onis et al., 2004).

Since 2006, the new WHO international standards, studied and proposed by the WHO Multicentre Growth Reference Study (MGRS), have started to be adopted internationally (http://www.who.int/childgrowth/). The new growth standards have been developed studying a larger sample of children coming from different countries in the world: Brazil, Ghana, India, Norway, Oman, and the USA. Children had been selected for following the same feeding principles and care Furthermore, new growth curves, for

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[1] **Comandini O**, Carmignani G., Cipriani A, Carmignani G., Mutegaya P., Marini E. Nutritional status of children from Bumbire island (Tanzania). Peer J. submitted.

Comandini O, Cabras S., Ssensamba J, Marini E. Nutritional status of schooling children in Uganda. In prep.

children and adolescent 5-19 years, have been constructed (de Onis et al., 2007).

Using a so differentiated sample of children but that were recommended to follow the same feeding principles and care, the MGRS resulted in prescriptive standards for the normal growth of a child wherever in the world. These new standards can be adopted everywhere also because this study demonstrated that children from any part of the world grow basically following the same pattern when their nutrition, health, and care needs are met (WHO, 2008).

Before discussing in details in the research on nutritional status of school children in Tanzania and Uganda, an initial section on the methods adopted for collecting and analyzing data used in both the cases is presented.

We refer to the following paragraphs on the research in Uganda and Tanzania for some specific methods used in the study.

3.2 METHODS

General information

For all the children measured, both in Tanzania and in Uganda, we have collected their name, age and the class attended. To all the children measured, a specific code has been assigned so to maintain the anonymity. All data have been used in aggregate form, without any indication of names and identity. In accordance with the Helsinki Declaration, as revised in 2008, the parents or the tutors of children, gave their informed consent to the study. This research has been approved in Tanzania and Uganda by the project was accepted by the respective ethics committees. Concerning child's age, we have obtained data from different sources (parents, teachers, parish, school or social workers registers). When only the child's age in years or the year of birth was given, we attributed as date of birth the middle of the year (July 1th).

For a subsample of children, in all the school visited, other personal data have also been collected. These included: family data such as the parent's presence and/or absence, their education, the number of siblings, the child's order of birth, the ethnicity.

In order to have a general view of the food consumed by the children or, at least, what kind of food they consider more familiar, for subgroups of children, we have also collected data on their dietary habits (food and beverages consumed the day before the interview) with the use of a very simplified "Daily Dietary Recall" method (Swindale and Bilinsky, 2006). For this purpose, we have showed to the children a picture representing 12 very common foods consumed in Tanzania and Uganda (Figure 3.1), and we have asked which of those foods they had consumed at breakfast, lunch and dinner the day before.

Only in The Need Home, one of the Ugandan school examined, a medical examination has been done by two physicians. This included: anamnestic data, stethoscope listening of heart and lungs, abdomen inspection for the presence of gastrointestinal symptoms (nausea, vomiting, diarrhea and abdominal pain). The presence of edema has also been checked. Orthodontic examination and the presence/absence of tooth decay has also been performed by an orthodontist.

Anthropometry

Anthropometric measurements (height, weight, skinfolds and head, calf and arm circumferences) were taken by experienced observers, following standard international criteria (Lohman et al., 1988; WHO, 2008). Children height has been measured using a standard anthropometer (SECA; 213) mounted at a right angle between the floor and a wall. Since all of the children measured were older that 2 years, the measurement of recumbent length has not been necessary. Children's weight has been collected using a professional mechanical scale (SECA, 762).

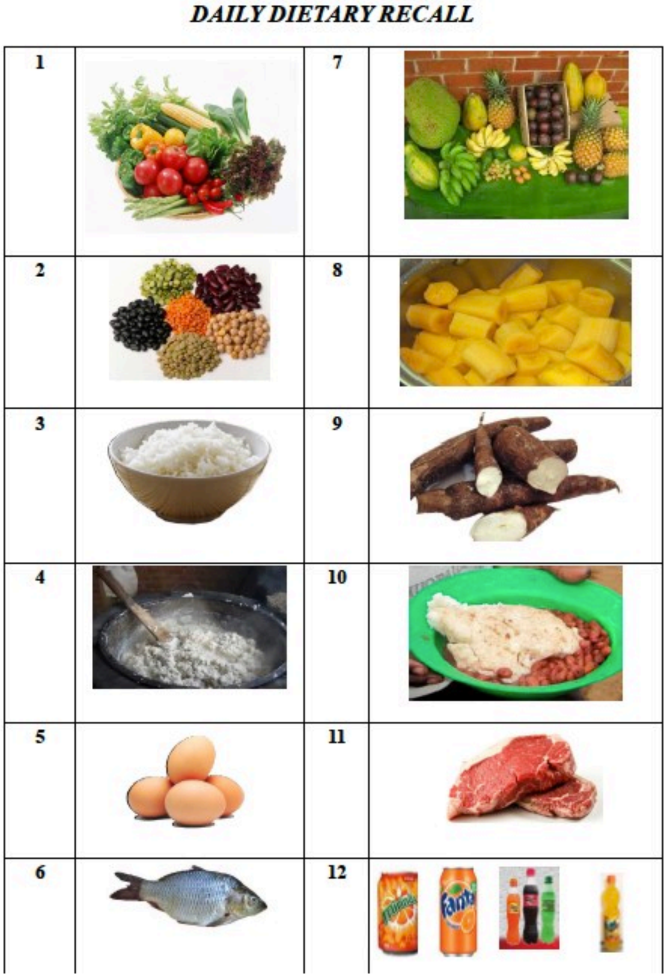


Figure 3.1. The picture represents the 12 very common foods consumed in Uganda and Tanzania that have been showed to the children to determine their nutritional style

We have deliberately chosen this kind of scale respect to an electronic one to avoid the use of batteries and problems related to their disposal that, in Africa, can represent an important ecological issue. In order to obtain accurate measurements, we have asked the children to remove their outer clothing and shoes before measuring. All circumferences have been measured using professional tapes. Skinfold thickness have been evaluated using a standard plicometer (Lange Skinfold Caliper).

Growth indices to assess nutritional status have been calculated according to WHO criteria (1995) and based on the WHO Child Growth Standards (http://www.who.int/childgrowth/, WHO, 2006). In particular:

- weight-for-age Z-scores: WAZ (for children 0-10 years);
- height-for-age Z-scores: HAZ (for children 0- 19 years);
- weight-for-height Z-scores: WHZ (for children 0-5 years);
- body mass index-for-age Z-scores: BAZ (for children 0-19 years);

and they are expressed in standard deviation units (s.d.) from the median of the reference population for the same sex and age, or height (WHO Child Growth Standards; WHO, 2006). Undernutrition is thus defined as an index below -2 s.d.:

- **stunting** (HAZ<-2),
- **underweight** (WAZ<-2),
- **wasting** (WHZ<-2),
- **thinness** (BAZ<-2).

Severe undernutrition is defined as the above indices below -3 s.d. On the other hand, overnutrition is defined as WAZ, WHZ or BAZ indices above +2 s.d. and obesity as values above +3. A careful analysis of all the four indices is fundamental to have a general view of the nutritional status of a person or a group, since each of them gives different and peculiar information on the reason of resulting type of malnutrition.

Stunting, defined as poor growth of height (length, in case of children under 2 years) for age, is the results of several determinants, including intra-uterine and post-natal undernutrition, especially during the first 2 years of life (de Onis et al., 2011; de Onis and Branca, 2016). Stunting implies an inadequate nutrients intake, especially micronutrients (Caulfield et al, 2006), for a long period (WHO, 2008). There is no agreement on the catch-up growth, i.e. if a child may recover his normal height with time, and if this is possible only during the childhood or also later (Checkley et al., 2003; Fink and Rokers, 2014; Schott et al., 2013; de Onis and Branca, 2016). However, it is generally believed that when stunting is tackled in a wrong way, e.g. by improving quantity of food and not its quality, the consequences may be an excessive weight gain, with an accompanying increasing risk of several chronic diseases (Victora et al., 2008).

Wasting is related to acute undernutrition, as a consequence of insufficient and inadequate food intake (both in terms of quantity and quality), or high incidence of disease and infections (especially diarrhoea) (WHO, 2010). The immune system functioning can be impaired by wasting, which can impact on the severity and duration of disease. Wasting is the only nutritional indicator for the calculation of which the correct knowledge of children in not necessary.

Underweight is the indicator most used in the past because weight is easy to measure (WHO, 2010). It is the indicator, together with wasting, that is linked more directly to a higher mortality risk of the affected children. However, if properly tackled, underweight can be totally recovered.

Finally, thinness, is defined as low body mass index for age. The BMI is the less used index, internationally, for determining child undernutrition, but it is much more used for overweight/obesity in adults. Only from 1995 WHO experts have started using BMI also for children thinness, and the introduction of the new cut off, allowed for a wider and international use of BMI (Cole et al., 2007) that can detect malnutrition, unlike wasting, also in late childhood and adolescence.

Statistical analysis

Since the statistical analysis carried out on data collected in Uganda and Tanzania are different, considering the peculiarities of the schools and environments in the two countries, the details of the different statistical methods used will be reported in each specific paragraph.

3.3 TANZANIA

The United Republic of Tanzania (Tanzania) is the largest country in East Africa, covering 940,000 square kilometers. Tanzania lies south of the Equator and shares borders with eight countries: Kenya and Uganda to the North; Rwanda, Burundi, the Democratic Republic of Congo, and Zambia to the West; and Malawi and Mozambique to the South. Tanzania has an abundance of inland water, with several lakes and rivers such as Lake Victoria that, with its more than 68.000 square kilometers, is the world's second largest lake.

- Population (CIA, 2017)

Tanzanian population is 51.045.882, with a presence of children 0-14 years of 44.34% and a presence of adults over 65 years of 2.97% (Figure 3.2).

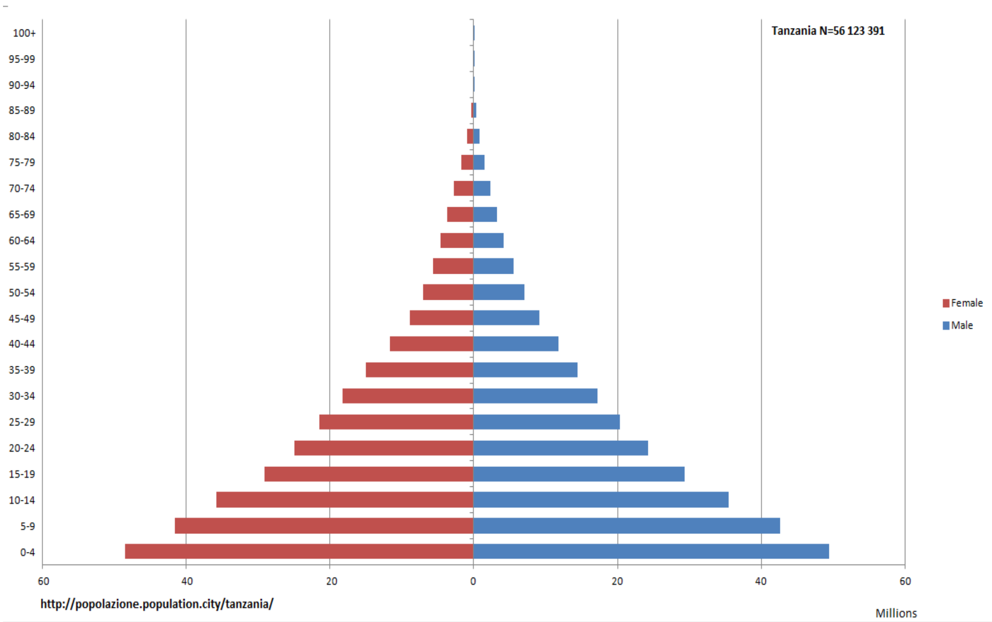


Figure 3.2 Distribution of the population in Tanzania according to gender and age. Data retrieved from: popolazione.population.city/tanzania/

Although the population of Tanzania has tripled in the past four decades, the country is still sparsely populated except in few parts. Infant mortality rate is 42.43 death/1000 live birth and life expectancy at birth is 61.71 years.

- Economy (CIA, 2017)

Tanzania has one of the lowest per capita income, but, because of the vast natural resources and tourism, the GDP 2009-2015 has grown at the significant rate 6-7% per year. The Tanzanian GDP-per capita in 2015 was $2,900. Tanzania has a mixed economy with an important role of agriculture (representing one-quarter of GDP and employing about 80% of the work force), animal husbandry, forestry, fishery and hunting. Recently, activities in service industry have improved representing now 10% of GDP.

- Education (TDHS, 2011)

In Tanzania most of population has same education but 27% of females and 18% of males have never attended school. Education attainment differs significantly among geographic regions and also between urban and rural residents (i.e., completed primary school of urban is 34.9% vs 27% for those living in rural area, 21.3% vs 5.3% for some secondary school).

- Population and family planning (TDHS, 2011)

Since 1992, the government of the Tanzania have started to adopt national and international policies that have had a direct effect on population and development. More recently, the revised 2006 National Population Policy has strived to improve the standard of living and quality of life of the population. The main goal of the policy was to direct development of other policies, strategies, and programs that ensure a real and sustainable development of all the people. Moreover, the "Reproductive and Child Health Strategic Plan 2008-2015" for reducing maternal, neonatal and child morbidity and mortality (according to the Millennium Development Goals number 4 and 5) has been implemented.

BUMBIRE ISLAND

The Bumbire archipelago, one of the many present in Lake Victoria, belongs to the Muleba District of Kagera Region (Figure 3.3). It is formed by 7 islands: Bumbire, Iroba, Kinagi, Nyaburo, Makibwa, Kerere e Goziba. On the basis of the last census, performed in 2003 by The Catholic Dioceses of Bukoba, people leaving in the archipelago have been estimated to be around 15.000. There is only one public ferry that connects the islands with the mainland, and it works three times/week. Each island has a small center with some basic commercial activities (Figure 3.4). Electricity is not present but some houses may have photovoltaic systems.

Figure 3.3 Bumbire archipelago is in Lake Victoria, one of the African Great Lakes. The lake is divided among three countries: Uganda, Kenya and Tanzania

In the archipelago there are five primary schools (Bumbire Primary school, Kajule Primary school, Kitua Primary school, Iroba Primary school, Kelebe Primary school, Goziba Primary school) but they are generally overcrowded and the buildings are often run-down (Figure 3.5). There are also three baby schools (Stella Maris Nursery school, Bumbire, Kelebe

Nursery Schools e Kishai Nursery school) and only one secondary school (Bumbire Secondary School).

Figure 3.4 Typical view of Bumbire with sparsely diffused simple houses

From a health point of view, the most frequent diseases affecting people are malaria, typhoid fever, amoebic infections and AIDS, which caused the death of several people increasing the number or orphans. In the entire archipelago there is only one public dispensary which offers irregular and poor services. The islands lack drugs and medical supplies (drugs sold are mostly pain killers) and competent medical staff. The nearest hospital is the St. Joseph's Hospital – Kagondo which is 15 km the inland (Bumbire, the island which is nearest to shore, is some 22 km far from the coast). Most of the people can't afford costs for trips and medical cares; moreover, public transportations are not available daily.

Figure 3.5 A classroom of a Primary School showing evident run-down problems

Bumbire Archipelago, because of its geographic, socio-economic, hygienic and sanitary peculiarities, represents a marginal and disadvantaged environment respect to the rest of Tanzania. For these reasons, children malnutrition may be present and have serious consequences, especially within those families where poverty, social emergencies, and diseases can make children conditions more fragile. Children malnutrition can hence represent a risk factor for the whole community. Moreover, the scarce perception of the severity of pathological conditions, the dissemination of care 'do-it-yourself" healthcare, the lack of preventive policies and appropriate people education, make the overall situation of Bumbire Archipelago even more problematic.

In this context, the research carried out for this PhD project aimed to tackle the problem of children malnutrition with a careful assessment of nutritional status of children, and the implementation of training and awareness activities, which could allow, in a next future, to make people able to handle and tackle their own problems. Furthermore, we also aimed to evaluate the longitudinal trend of children nutritional status and the possible effect of awareness actions. We also checked the precision of birth date data, whose knowledge is necessary to properly evaluate nutritional status.

The sample

Two surveys were carried out in July 2014 and July 2015 in the Baby and Primary schools on Bumbire island. The project was approved by the Muleba District Council, Kagera, Tanzania (7/5/2010) and by the Bukoba Catholic Diocese (25/10/2013). In accordance with the Helsinki Declaration, as revised in 2008, the parents or the tutors of children, gave their informed consent to the study.

A total of 423 children (219 males and 204 females), aged 3 to 16 years were measured (Figure 3.6). Child's age was collected from different sources (parents, teachers, parish, school or social worker registers). When only the child's age in years or the year of birth was given, we attributed as date of birth the middle of the year (July 1th).

In a sub sample of 126 children, information on age was collected in both the surveys, so that a check for the accuracy of the date of birth was made possible. Children showing a divergence not higher than 1 year between the information collected in 2014 and 2015 were included in the sample, attributing them an intermediate age. Children with an error of magnitude higher than a year were excluded from the analysis of nutritional status.

The final cross-sectional sample used for the global analysis of nutritional status was composed by 423 children of both sexes, i.e. quite all those attending the schools (Table 3.1). Measurements taken in 2015 were preferentially used for children measured both in 2014 and 2015.

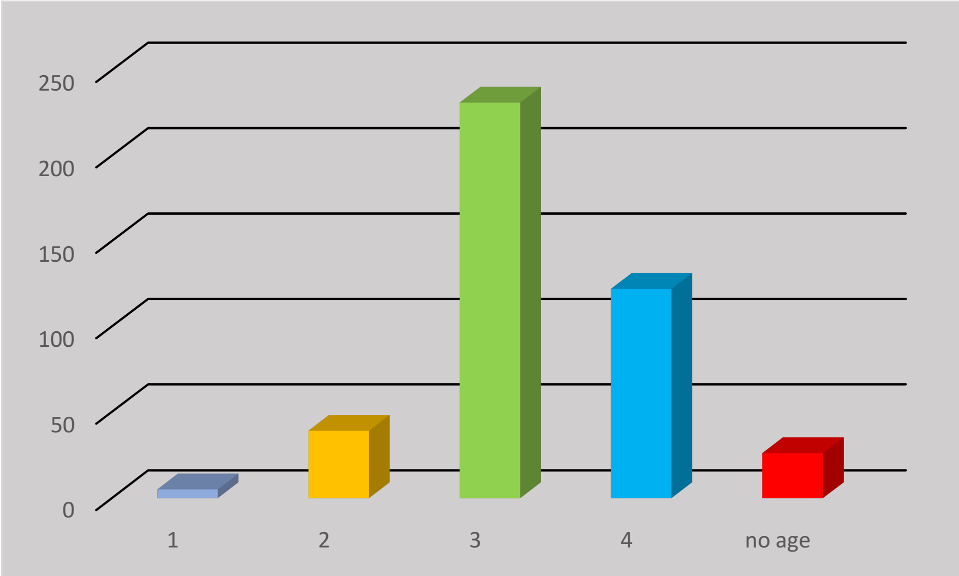


Figure 3.6 Sample composition of all the 423 children measured in Bumbire island divided for age classes.

Table 3.1 Detailed information of the sample composition of children measured in 2014 or 2015

Age class	Females	Males	Total
1	3	2	5
2	18	19	37
3	112	121	233
4	62	60	122
No data on age	9	17	26
Total	204	219	423

Legend: 1, ≥ 3 years and ≤ 5 years; 2, > 5 y and ≤ 7 y; 3-females, > 7 y and ≤11 y; 3-males, > 7 y and ≤ 12 y; 4-females, > 11 y and ≤ 16 y; 4-males, > 12 y and ≤ 16 years.

A sub sample of 126 children measured twice were then analyzed for studying the longitudinal changes of nutritional status.

Age groups were defined considering stages in human growth (Bogin, 2001), modified according to patterns of sexual maturation: childhood (two groups: ≥ 3 y ≤ 5 y and > 5 y ≤ 7 y; juvenile: > 7 y and ≤11 y (females) and

> 7 y and ≤ 12 y (males); puberty: > 11 y and ≤ 16 y (females) and > 12 y and ≤ 16 y (males).

Data collection

For all the children measured, information on sex and age (exact date of birth, when possible) have been collected. Moreover, for a subsample of 47 children socio-demographic data (ethnicity, parent's presence or absence, parent's education, number of siblings, child's order of birth) have been reported together with their dietary habits (food and beverages consumed the day before the interview) by means of a simplified Daily Dietary Recall (Swindale and Bilinsky, 2006). Anthropometric measurements have been collected following standard international criteria (Lohman et al., 1988, WHO, 2008).

Statistical analysis

Two-factor ANOVA was applied to compare nutritional status in children of different sex and from different groups of age. In the subsample of children with socio-demographic data, a multivariate linear regression (MANOVA) was performed to analyse the effect of the presence of parents, education, order of birth, and number of siblings on nutritional status. A paired samples *t*-test was applied to analyse variations of nutritional status in children measured in 2014 and 2015.

Awareness actions

The explicative material for the population (posters and booklet) was prepared largely using publications by WHO and UNICEF, selecting and reassembling parts of them (after obtaining specific permissions), relative to malnutrition issues, and combined with personal comments and iconographic material.

Results

Information on age, family data and Dietary Recall

A percentage of 94.4% of children from Bumbire island had some an information on their date of birth, that was in most cases precise. In fact, in the sub sample of 126 children where double information (2014 and 2015) on age was available, 105 children (83.3%) showed consistent information on age, only 14 children (11.1% of the sub sample) showed an error of magnitude higher than a year, while seven others (5.6%) showed a divergence not higher than 5 months. The age error was equal on average to 0.4 months (± 1.2), ranging between few days and 8.5 months.

In the sub sample of 47 children interviewed for family data, six children were orphans of father or mother. The majority of fathers (35) had a complete primary education, some others (6) have no completed the primary school, and only 4 attended some secondary schools (Figure 3.7a). As for the mothers 32 of them had completed the primary school, 10 of them had no a formal education, and only 3 attended some secondary schools (Figure 3.7b).

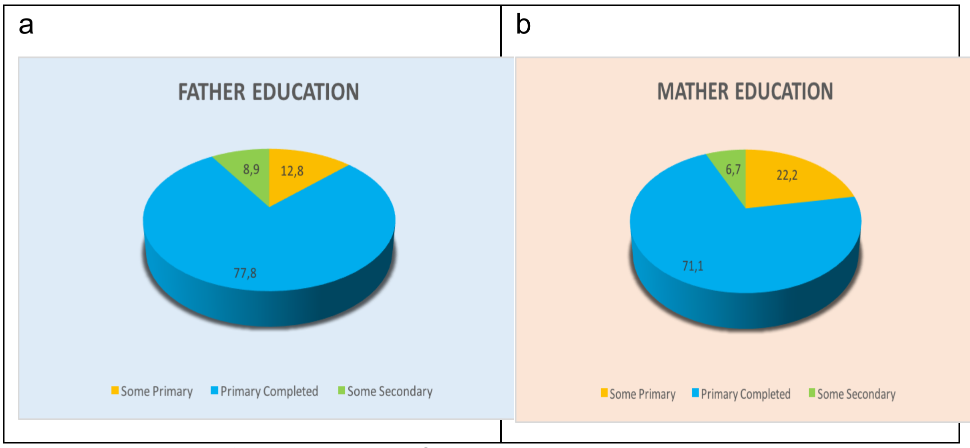


Figure 3.7 Prevalences of parents education in Bumbire island

The mean number of children per family was 6.3 (±3.2), ranging from 1 to 13 children. From analysis of data collected with the "Daily Dietary Recall" interview, all the children answered about the type of food consumed the day before, but most of them had difficulties in quantifying the amount. Twenty-eight of the 47 children interviewed had three meals a day (17 children had no breakfast); one child had only dinner, but he was a Muslim and we collected data during the Ramadan period (Figure 3.8).

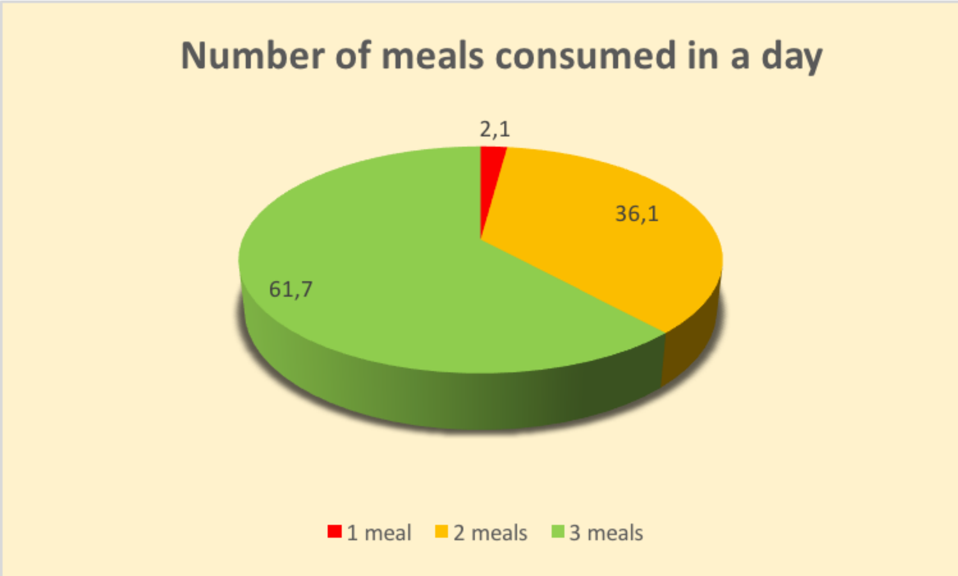


Figure 3.8 Prevalences of children consumed one, two or three meals in the subsampled interviewed for the Dietary Recall

Further, 41 (87.2%) children interviewed consumed proteins at least one time a day, 20 of those (48.8%) have eaten fish or pulses both at lunch and dinner and 4 of them (8.5%) even three times a day. Four children (8.5%) only have eaten meat. The use of fruit seems to be uncommon and sporadic, and four children (8.5% of the total) have eaten some fruit collected along the way to school.

Nutritional status

Children showed values indicative of a tendency to undernutrition. In fact, negative mean values of nutritional indices (ranging from -0.3 for WHZ to -1.4 for HAZ, considering both sexes) and a high prevalence of undernourished and severely undernourished children (from about 5% for wasting to more than 30% for stunting) were observed (Table 3.2). Few males were overweight, all of them being also stunted. To be noted that WHZ was calculated in a subsample composed quite entirely (96.0%) by children of more than 5 years of age (range: 3.4 to 10.2 years).

Table 3.2 Prevalences of malnutrition in all the children measured, in males and females using the different nutritional indices

	N	Mean	s.d.	< -2 (%)	< -3 (%)	> 2 (%)
HAZ						
total	397	-1.42	1.08	30.7	5.8	0.0
males	202	-1.52	1.05	35.1	6.4	0.0
females	195	-1.32	1.09	26.2	5.1	0.0
WAZ						
total	201	-0.98	0.95	12.9	1.0	0.0
males	97	-0.97	0.94	12.4	1.0	0.0
females	104	-0.99	0.97	13.5	1.0	0.0
WHZ						
total	126	-0.28	0.95	4.8	0.0	2.4
males	65	0.01	0.96	3.1	0.0	4.6
females	61	-0.60	0.83	6.6	0.0	0.0
BAZ						
total	396	-0.57	0.80	4.5	0.0	0.0
males	201	-0.54	0.82	4.0	0.0	0.0
females	195	-0.61	0.77	5.1	0.0	0.0

Legend: HAZ: height-for-age Z-score; WAZ: weight-for-age Z-score; WHZ: weight-for-height Z-score; BMI: body mass index; BAZ: BMI-for-age Z-score.

Undernutrition showed a different pattern in the different age classes and, to a lesser degree, between genders (Table 3.3). In fact, age had an influence on all the indices, with lower z-scores in higher age groups for both males and females. Gender differences were present for HAZ and WAZ, with males showing the worst conditions. The differences were especially due to children in class II, as indicated by the significant interaction between age and gender.

Table 3.3 Two-factor ANOVA for the comparison of nutritional status between age and sex classes

	Age class 2		Age class 3		Age class 4		comparison (F)		
	Males	Females	Males	Females	Males	Females	sex	age	sex x age
	Mean (sd)	Mean (sd)	Mean (sd)	Mean (sd)	Mean (sd)	Mean (sd)	*p*	*p*	*p*
HAZ	-1.19 (0.95)	-0.64 (1.02)	-1.34 (1.02)	-1.40 (1.00)	-1.92 (0.96)	-1.40 (1.21)	0.002	0.000	0.009
WAZ	-0.79 (0.82)	-0.50 (0.97)	-0.97 (0.89)	-1.11 (0.86)	--	--	0.013	0.002	0.017
BAZ	-0.04 (0.74)	-0.15 (0.75)	-0.44 (0.79)	-0.55 (0.74)	-0.89 (0.72)	-0.89 (0.75)	0.240	0.000	0.313

For the legend see Table 3.1 and Table 3.2

In the subsample where family data have been collected, the multivariate regression showed no significant effect due to the presence of parents, number of siblings or order of birth on child nutritional status. The one-year longitudinal analysis indicated that only HAZ showed a significant change in nutritional status (p=0.000), with values worsening of 0.2 z scores in mean in a year (Figure 3. 9 and Table 3.4). The prevalence of stunting changed accordingly (2014: 30%; 2015: 37%).

In collaboration with the local public and religious organizations, and with the Bhalobasa onlus, we have organized meetings with the families, which have been attended by numerous parents. We have discussed the problem of child malnutrition (both under- and overnutrition) and how it influences a proper physical and cognitive growth and hence the future of the children. We have also showed explicative posters and distributed a booklet on the main, but simple, daily habits that may contribute to fight child malnutrition (Comandini et al., 2014). For further detail see Chapter 4.2.

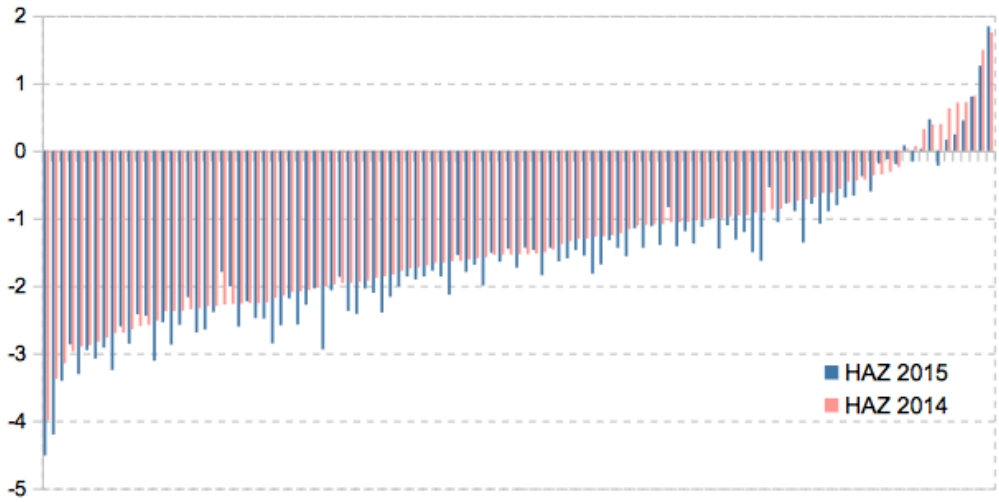


Figure 3.9 z-scores referred to HAZ valuated in 2015 (blu) and in 2014 (red) showing worst values in 2015

Table 3.4 Student's t-test, paired data, for the comparison between nutritional indices calculated in 2014 and 2015

	2014			2015		t-test	
	N	mean	d.s.	mean	d.s	t	p
HAZ	113	-1.42	1.01	-1.63	1.06	-8.812	0.000
WAZ	36	-0.93	0.89	-0.91	0.81	0.273	0.786
WHZ	15	-0.35	1.13	-0.19	1.02	1.259	0.228
BAZ	113	-0.64	0.87	-0.67	0.76	-0.532	0.596

For the legend see Table 3.1 and Table 3.2

Discussion

Knowledge on the age of children from Bumbire island was quite accurate (reaching 94.4%), probably due to the availability of Catholic parish registers, where the births of children, regardless of their religious beliefs, are regularly annotated. Although these data are not directly comparable to those reported in civil registers of births, the scenario at Bumbire seems to be better than in the rest of Kagera region, the whole Tanzania, or sub-Saharan Africa, where birth registration of children under 5 years of age, in 2010, was 6.7% (TDHS, 2011), 16.3% (TDHS, 2011) and 44.0% (UNICEF, 2013b), respectively. It also appears to be better than that observed in children from Ugandan poor settlements, where a lower percentage (79.8%) of children with some information on age and a noticeably wider age span of error (7.5 months in mean) have been observed (Comandini et al., 2017). The accuracy of birth data in Bumbire's children allows the confident use of nutritional indices based on age, such as HAZ, WAZ, and BAZ, which are unreliable when age data are imprecise or biased (Comandini et al., 2016; Comandini et al., 2017).

Bumbire children showed a tendency to undernutrition, especially to stunting, and to a lesser degree to underweight and wasting. Overweight was rare and obesity absent. The pattern of undernutrition is consistent with the global one, as stunting shows higher and wasting lower prevalences than underweight worldwide, respectively (WHO, 1995; UNICEF, WHO & The World Bank, 2016). Wasting indicates recent or continuing weight loss and underweight refers to a mixed situation, implying stunting or wasting, or both of them (WHO, 1995).

The different prevalence of nutritional indicators can be due to causal factors that affect stunting but not wasting. For example, children with a sufficient food intake in terms of energy, but not of quality (lack of micronutrients), grow in weight, but not proportionately in height. Moreover, the recovery of weight is more simple, rapid and effective than that of height. The poor linear growth implies long term undernutrition and can be also due to particular limiting factors, such as the lack of micronutrients (especially, zinc, iron, vitamin A) (Caulfield et al., 2006; Wilson et al., 2011 and references within), while wasting indicates recent or continuing weight loss, and underweight refers to a mixed situation, implying stunting or wasting, or both of them (WHO, 1995). Stunting prevalence can be higher also because the recovery of weight is more simple, rapid and effective than that of height. When catch up of stature is not totally compensative, stunting can remain and cumulate its prevalence.

Noteworthy, even if the critical windows for stunting goes from conception through the first years of life (de Onis and Branca, 2016), growth faltering has been observed in the later childhood and early adolescent years (Fink and Rockers, 2014). Concerning the prevalence of wasting (4.8%), it has to be noted that it can only give a general information on the true diffusion of this condition within Bumbire children. In fact, the WHO growth charts for WHZ are constructed for children under five years of age, whose range of height is presumed to be within 120 cm. Instead, in order to recognize all wasted children, we have calculated weight-for-height z-scores whenever possible, i.e. in all children with a height lower than 120 cm, regardless of their age. The majority of these children actually were above 5 years, hence they were also showing a more or less accentuated stunting. Hence, our prevalence of wasting is not directly comparable among sub-groups of children nor with literature results. However, the percentages of undernutrition calculated with BAZ (4.5%) are coherent and are even more informative, considering that BAZ covers a wider range of age (0-19 y). To be noted that both WHZ and BAZ are necessary to recognize overweight or obese children, who would could not be detected by WAZ, if they are stunted. This is a very important point, as the worldwide trend of increasing obesity, even in countries traditionally affected by undernutrition (Ng et al., 2014), needs to be promptly dealt with. This condition is still very rare among Bumbire children.

Indeed, even if sharing some common causes, such as insufficient energy intake and infections, nutritional indicators of growth impairment can be due to different causal factors and describe undernutrition from different points of view.

To the best of our knowledge, most of the research on child nutritional status in Tanzania is based on under five children (e.g., Chirande et al., 2015; Makoka and Masibo, 2015; Nordang et al., 2015; Semali et al., 2015; Sudfeld et al., 2015; Lawson et al., 2016). Other researches are focused on newborns (e.g., Kulwa et al., 2015; Safari et al., 2013), on children with diseases (Juma et al., 2016), such as HIV (e.g., McDonald et al., 2012; Sunguya et al., 2011, 2014) or malaria (e.g., Mboera et al., 2015), or on nutritional treatments (Lachat et al., 2015). Instead, researches on the nutritional status of the general population of children older than five years are scanty (Mosha and Fungo, 2010; Mpembeni et al., 2014). Furthermore, for some remote areas no information is available.

Although the comparison with data from the Tanzanian DHS (2011) is not completely appropriate because of the different age range of children examined (5-16 years vs. 0-5 years) and the period of surveys (2014-15 vs. 2010), Bumbire children show better nutritional conditions, in comparison to both whole Tanzania (stunting: 42%; wasting: 4.8%; underweight: 15.8%; overweight: 5.2%) and Kagera region (stunting: 43.6%; wasting: 5%; underweight: 17.1%; overweight: 3.1%) (TDHS, 2011). On the other side, Bumbire children are more frequently undernourished than children 6-9 years from two metropolitan areas, that show strongly lower values of stunting and underweight (near 4% for both indicators) (Mosha and Fungo, 2010). These urban children also show higher rates of overweight (near 8%) and a not trivial prevalence of obesity (near 4%). It can be hypothesized that Bumbire poor insular environment furnishes relatively more high value alimentary resources (in particular, proteins from fishes) than inland regions. Indeed, in Bumbire the children diet appears to include a greater variety of essential nutrients, even a low consumption of meat or fruits and vegetables (as generally occurs worldwide, particularly in low income countries; 2016; Hall et al., 2009; Krebs et al., 2011 Miller et al., 2016) was detected. However, their levels of undernutrition are still objectively high, and higher than those of Tanzanian urban children. A possible explanation of this condition could be likely linked to a scanty amount of food, and of micronutrients, that children and their families consume daily. On the other side, Bumbire island children have less access to junk foods than children living in urban aggregates, where transport facilities, markets and marketing make such goods desirable and affordable. For these reasons, they do not present the problems of overnutrition (as indicated by both WHZ and BAZ), that are appearing among urban children. Indeed, overweight has been noticed in Tanzanian DHS from 2010, and, even if the prevalence is still relatively low with respect to middle- or higher-income countries, this result is consistent with the worldwide trend of increasing obesity, even in countries traditionally affected by undernutrition (Ng et al., 2014).

The 1-year longitudinal analysis indicated an increase of stunting prevalence, while wasting and underweight did not change significantly. Consistently, Bumbire children with higher ages showed worst nutritional status than younger ones. This confirms that the diet of Bumbire children is not completely adequate in terms of quantitative intake of nutrient rich food (proteins and vitamins) and not sufficient to a proper linear growth. It also appears that awareness actions on families, although representing important moments of discussion on malnutrition issues where mothers and fathers felt free to express their opinions, doubts, or questions, have not still showed an effect. However, we are conscious that more time and constant efforts are necessary to produce a perceivable effect.

Instead, the historical trend for the total Tanzania and Kagera region retrieved from DHS indicates a something different scenario, with a reduction of the prevalence of underweight, an unstable trend of reducing stunting, and a quite stable prevalence of wasting (Figure 3.10).

However, the apparent inconsistency in the trend of stunting prevalences can be explained considering that children considered in DHS are under 5 years only, while in this research the majority of children are over five years of age and at these ages, as previously discussed, the recovery of height is more difficult. Moreover, the range of time considered by subsequent DHS is 5 years or more, while in our research we have only analysed a span of 1 year.

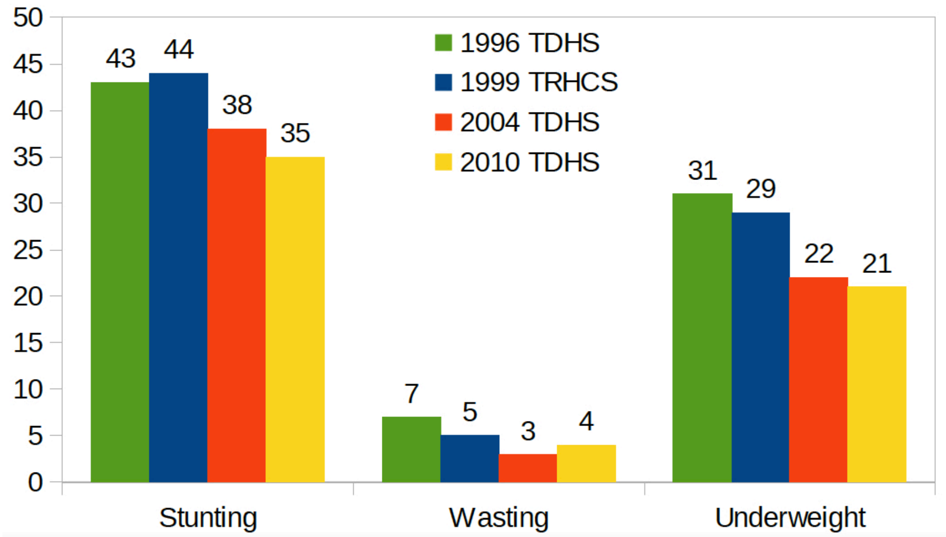


Figure 3.10 Historical trend of malnutrition prevalences of the different indices retrieved from Tanzania Demographic and Health Surveys

This research has some points of strengthen. First, almost all children from the island have been included in the sample. Further, at the best of our knowledge, this is the one of the very few nutritional researches where the problem of age imprecision has been considered and analysed. Last, but not least, the collaboration with a NGO represents a useful approach for dealing with the public issue of malnutrition, adding concreteness to scientific results.

The main limitations of this work, instead, relate to the use of the Daily Dietary Recall, whose efficacy in describing the nutritional habits has been frequently questioned (Dhurandhar et al., 2015). We are conscious that children may have forgotten some food or may have indicated foods not really consumed, for having been influenced in their answers by each others. However, qualitative information can be retrieved by this analysis, as for example which kind of foods are more familiar and which ones are not frequently consumed.

Another limitation refers to the prevalence of wasting (4.8%), that can only give a general information about the true diffusion of this condition within Bumbire children. In fact, the WHO growth charts for WHZ are constructed for children under five years of age, whose range of height is presumed to be within 120 cm. Instead, in order to recognize all wasted children, we have calculated weight-for-height z-scores whenever possible, i.e. in all children with a height lower than 120 cm, regardless of their age. The majority of these children actually were above 5 years, hence they were also showing a more or less accentuated low stature for age. For this reason, our prevalence of wasting is not directly comparable among sub-groups of children nor with literature results. However, we have used these data because the coherent percentages of undernutrition calculated with BAZ (4.5%) indirectly confirm them and because this index is not influenced by age error and (with BAZ) it is necessary to recognize overweight or obese children.

3.4 UGANDA

Located in East-Central Africa, the Republic of Uganda covers an area of 241.038 square meters. It lies astride the equator and shares borders with Kenya (east), Democratic Republic of the Congo (west), South Sudan (north), Rwanda and Tanzania (south) (Figure 3.11). The climate, favorable because of the relatively high altitude, is mainly tropical, with the presence of two dry seasons; it is semiarid in the northeast part of the country.

Figure 3.11 Map of the Republic of Uganda

- Population (CIA, 2017)

Ugandan population is 38.319.882, with a presence of children 0-14 years of 48.5% and a presence of adults over 65 years of 2%. Uganda has one of the youngest and most rapidly growing populations in the world (Figure 3.12). The fertility rate is one of the highest, with 5.8 children for woman. Infant mortality rate is 57.6 death/1000 live birth, and life expectancy at birth is 55.4 years. Because of the high number of births, the short birth intervals and the very young median age for the first pregnancy (18.9), also the maternal mortality rate is very high (343 deaths/100.000 live births).

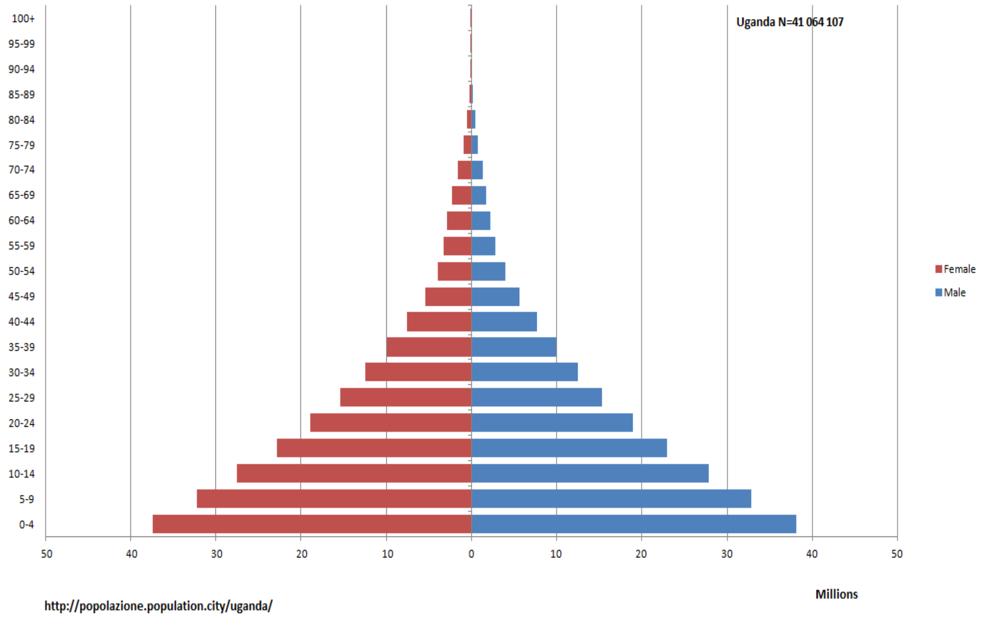


Figure 3.12 Distribution of the population in Uganda according to age. Data retrieved from: popolazione.population.city/uganda/

It has been reported that about 16% of the Ugandan population lives in urban areas, 54% of those live in the slums (WHO, 2017). Kampala is the capital and the greater city; has a population of about 2 million, making some 40% of the total Ugandan population. The high level of overcrowding in urban areas leads to important economic and social issues that this country has to tackle, such as the need to plan and manage urban growth, a high level of poverty, and also the existence of political conflicts due to the massive presence of rural migrants in urban areas (Werike, 2017).

- Economy (CIA, 2017)

Agriculture is the most important sector, employing about one third of the total Ugandan population (main products are coffee, tea, tobacco, cassava, potatoes, corn millet, pulses, cut flowers). Large reserves of copper, gold, and other minerals and oil are also important resources that contribute to Ugandan economy. The industrial sector in the country is not particularly developed and it focuses on products such as sugar, brewing, tobacco, cotton textiles, cement, steel production. Uganda has one of the lowest per capita income in the world ($ 2.100), but because of the past reforms and the growing of urban consumer population, economy has largely improved in the last 10 years.

- Education (UDHS, 2012)

Most of the Ugandans have either no formal education or only some primary education. In fact, although primary schools are free, yet 33% of girls and 34% of boys 6-9 years have never attended school. Differences in the education level are present between urban and rural areas (8.2% of people in urban areas vs 22% in rural areas have no education; 40.9% in rural area vs. 60.9% in urban have a primary education), but also among the different regions of the country (50.1% of people have no education in Karamoja region vs 5.3% of people without education in Kampala). There are no gender differences in the education levels. The main determinants for the poor school attendance seem to be to the long distances to and from schools (especially in rural areas) and the costs of education (for private or secondary schools). Moreover, in some parts of the country, children under 8 are still considered too young for attending schools.

- Population and Health planning (CIA, 2017)

The first Uganda's National Population Policy, with the aim to improve the quality of people's life, was promoted in 1995. Since then, some important targets have been achieved. A National Population Action Plan was also developed at the subnational level. Several Health Sector Strategic Plans (HSSP) have been planned and developed since 2000 with the major aim to accelerate Ugandan economic growth and reduce poverty (UDHS, 2012).

Since 1982, there has been a devastating epidemic of HIV/AIDS in Uganda, especially in the Rakay District, which led to a huge number of deaths and orphans and, consequently, caused an important social and economic destabilization (Kikafunda and Namusoke, 2006). Several efforts have been made in the last decades in order to tackle this important issue and amend its effects. The Uganda national strategy on SRH (Sexual and Reproductive Health), HIV/AIDS and MH (Maternal Health) service integration provides services on HIV prevention, care and treatment

(Johnson, Varallyay, Ametepi, 2012; Ahumuza et al., 2016). Notwithstanding all these focused actions and the good results obtained so far, there are still 7.25% of Ugandan adults affected by HIV/AIDS, and Uganda is ranked 10 among countries in the world for this disease.

- Political history (UDHS, 2012; CIA, 2017)

When Ugandan boundaries were fixed, in the late 19th century, a diverse array of ethnic groups and tribes with very different cultures, some of which with ancient contentions and unsettled disputes, was brought together. For these reasons, when Uganda obtained independence from Britain, in 1962, the establishment of a solid political community was very difficult to achieve, and the country resulted to be vulnerable to dictatorial regimes that followed each other for about the next 20 years. The dictatorial regime of Idi Amin (1971-1979) was responsible for the death of about 300.000 people. Milton Obote (1980-1985) regime was characterized by guerrilla war by tribally-based local kingdoms, and claimed some additional 100.000 lives. The security forces of Uganda under President Obote had one of the world's worst human rights records. With the rule of Yoweri Museveni, in 1986, Uganda has started to experience a relative stability. The new government ended human rights abuses and instituted broad economic reforms that gave the start to a significant economic growth; political liberalization and freedom press also received a positive impulse. Armed resistance against the government has, in any case, continued in northern areas of the country. However, in the last few years, peace has started to return and people living in internally displaced camps have started settling back in their villages.

In the last decades, Uganda has seen a unique phenomenon: it has been a country with high levels of emigration and were many people were forced to live as refugees abroad, but, at the same time, it has hosted refugees and migrants from other countries. In fact, starting from the 1950s, because of the conflicts within neighboring states, thousands of refugees have moved to Uganda and still are doing so. Recent data report that Uganda is hosting about 600.000

people from South Sudan (refugees and asylum seekers), 200.000 people from Democratic Republic of the Congo, 40.000 from Burundi, 40.000 from Somalia (refugees and asylum seekers) and 15.000 people from Rwanda. At the same time, from the 1970s, thousands of Ugandans have emigrated, mainly to southern or western Africa, for security problems, to escape poverty, to search for jobs, and for access to natural resources. Many of the fleeing people were doctors and nurses, which led to a shortage of skilled health care workers.

- Natural disasters

Numerous different disasters have affected Uganda: famine as a results of drought, earthquakes, disease epidemics, livestock and crop diseases, flooding and others (Department of Management and Refugees, 2017). The severe drought that affected East Africa region between 2011 and 2012, struck also Uganda and Karamoja region and the Balambuli district in particular, with an estimated 1.2 millions people involved. (http://allafrica.com/stories/201108190282.html). Moreover, about 68% and 9.8% of mortality between 1990 and 2014 are attributable respectively to landslides and floods, respectively (http://www.preventionweb.net/countries/uga/data/).

The research

We have decided to study the nutritional status of children attending four Ugandan primary schools with which Bhalobasa has established cooperative contacts in recent years. Because of the variability and complexity of Uganda, we have also tried to select study areas that could represent some diverse situations characterized by different social and environmental conditions. In this way, we aimed to study if or how these differences could influence the nutritional status and growth of children. This project was planned with the Bhalobasa NGO and approved by the association of Ugandan schools “Kwagala” (April 2012, Kampala, Uganda).

In accordance with the Helsinki Declaration, as revised in 2008, the parents or the tutors of children, gave their informed consent to the study.

The schools

The two surveys were carried out in July 2014 and July 2015 in four Ugandan Primary private schools located in the central region of Uganda.

The Nakinyuguzi Parent's School (Figure 3.13) is located in the Kampala District, 5 km from the city centre. Children attending the school come mainly from middle class families. Children coming from lower class families are generally supported by Bhalobasa. All children have the lunch at school. Baby and Middle class have also a snack (porridge) in the morning. No boarding services are available.

In Need Home School (Figure 3.14). "In Need Home" (INH) is a not-for-profit organization, founded in 2003, with the aim to provide home support, care, protection and education to orphans and others vulnerable children so to realize their full potential in life. INH also supports and works in order to improve conditions of children's families, especially women that mainly manage responsibilities of the family. In Need Home organization and its school are located in Namuwongo slum, one of the biggest in Kampala, and all of the children attending the school come from the slum, some of them being supported by Bhalobasa. All the children attending the school have breakfast and lunch at school.

The Marengoni Primary School (Figure 3.15) is located in Luweero, Nakaseke District, in Kikkumango Community, a rural area 60 km North from the capital. Children attending the school mainly come from low social class and are supported by Bhalobasa sponsorships. All children have the lunch at school. A small group of students (30 children) are boarding.

Gossace Primary School (Figure 3.16) is located in Mukono District, in Golomolo Community, an agricultural area 35 km South-East far from the capital. Half of the students are boarding. Children mainly come from low class families, most are orphans and are supported by Bhalobasa sponsorships

Figure 3.13 Nakinyuguzi Parent's School in Kampala
Photo by Gianluca Caboni

Figure 3.14 In Need Home School, close to Namuwongo slum in Kampala
Photo by Eleonora Marrocu

Figure 3.15 Marengoni Primary School in Luweero.

Figure 3.16 Gossace Primary School in Golomolo
Photo by Gianluca Caboni

Methods

Information on age, family data and Dietary Recall

All the data have been collected according to the methods already explained in Methods 3.2. In INH school, a medical examination has be done by two physicians: Gabriele Carmignani (Bhalobasa) and Jude Ssensamba (In Need Home). This included: anamnestic data, stethoscope listening of heart and lungs, abdomen inspection for the presence of gastrointestinal symptoms (nausea, vomiting, diarrhoea and abdominal pain). The presence of oedema has also been checked. Orthodontic examination and the presence/absence of tooth decay has also be performed by Diego Pietra Caprina.

Anthropometry

Anthropometric measurements have been taken according to international criteria (Lohman et al., 1988; WHO, 2008). The main anthropometric indices to assess a child nutritional status have been calculated according to WHO international criteria and standards (WHO,1995; WHO, 2006; de Onis et al., 2007).

Statistical analysis

Because information on children age data collected from different sources were frequently incomplete or inconsistent (for a more detailed analysis see Chapter 2.3 and Comandini et al., 2017), malnutrition prevalence has been calculated considering the effect of age imprecision. To this purpose, three different variables describing age have been defined as follows.

- Age declared: the age registered at the moment of the measurement (in most cases, the one available from school archives).
- Age attributed: an age arbitrarily assigned, on the basis of the analysis of different sources of information, and according to the following criteria. When only the child's age in years or the year of birth was given, we assigned the date of birth as July 1st (middle of the year). When different

sources were present, we assigned the mean age, or chose one for being evidently more accurate than the others (such as when one date was complete of day, month, and year, and the other ones reported only the year). When the difference between different sources (both complete and incomplete) was higher than 2 years, the case was excluded from the analysis.

- Age bootstrap: the age deriving form 10000 bootstrap replicates, considering all the sources of data equally.

A Pearson's chi-squared test with simulated p-value (based on 10000 replicates) was applied to compare age distribution within schools. Malnutrition prevalence in the two genders (based on WHZ, WAZ, BAZ, HAZ), among age classes and among schools (considering age groups) were compared using bootstrap analysis. Longitudinal analysis was performed using the age attributed and comparing malnutrition indices, calculated in 2015 and 2014, with a paired *t*-test. Two-factor ANOVA was applied to compare the change of nutritional status (as indicated by the difference between nutritional indexes calculated in 2015 and 2014) in children of different schools and from different groups of age.

Awareness actions

Also in the Ugandan schools, the same awareness actions already explained for Tanzania have been carried out. In the Gossace and Marengoni schools meeting with teachers and caregivers started in 2012, during our first visit in Uganda. For detailed information on the actions carried out see Chapter 4.2.

The sample

A total sample of 1056 children of both sexes, representing more than 90% of children attending each school, was measured (Figure 3.17). The great majority of children, in all the schools, belonged to the Bantu ethnic-linguistic group (Nurse and Derek, 2006).

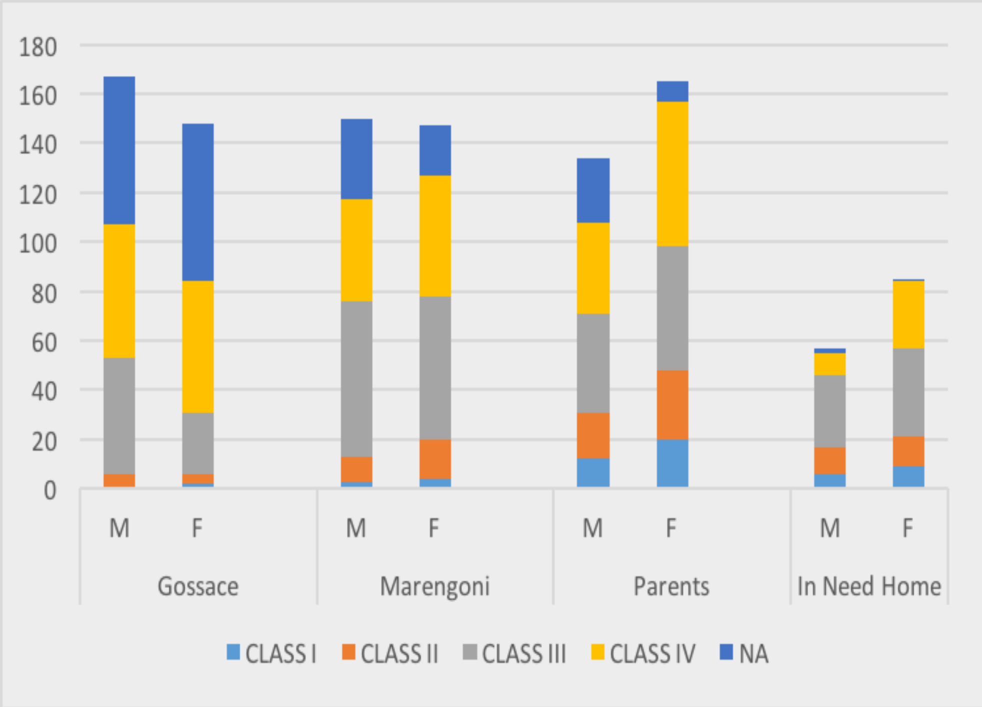


Figure 3.17 Characteristics of the 1056 Ugandan children measured in the four schools, differentiated for gender and age class. Ligh Blue = class I, Orange = class II, Grey = class III, Yellow =class IV, Blue = no birth data

Legend for age classes: I, ≥ 3 years and ≤ 5 years; II, > 5 y and ≤ 7 y; III-females, > 7 y and ≤11 y; III-males, > 7 y and ≤ 12 y; IV-females, > 11 y and ≤ 16 y; IV-males, > 12 y and ≤ 16 years

Two hundred and twenty-five children were excluded from the analysis because of the lack of information on their age, or because its great level of imprecision (variation between two different sources > 2 years). The final sample of 831 children is described in Table 3.5.

Table 3.5. Sample composition of the 831 children examined for nutritional status

	Gossace		Marengoni		Parent's		In Need Home		Total	
Age class	M	F	M	F	M	F	M	F	M	F
I	1	2	3	6	10	19	6	11	20	38
II	5	4	11	14	20	28	11	11	47	57
III	47	25	61	57	41	49	29	37	178	168
IV	54	54	41	47	32	59	9	27	136	187
Total	107	85	116	124	103	155	55	86	381	450

Legend: as in Figure 3.14

Results

Family and dietary data

Nakinyuguzi Parent's School

A subsample of 190 children have been interviewed for family data. The 96.3% of the children had their fathers living in the same household while the 3.7% of fathers were absent of dead. The presence of the mothers was very high (95.2%) too and only the 4.8% of them were absent or dead. The mean number of siblings for family was 3.7 (s.d. = 1.98) and the higher number of siblings for family was 10. As for the education level of the parents the 45.7% of the fathers and 41.2% of the mothers had no formal education. Had instead a primary education the 20% of the fathers and the 42.6% of the mothers; had a secondary education the 28.6% of the fathers and 13.2% of the mothers. Only the 5.7% of the fathers and the 3% of the mothers had a university level education. In this school we could not interview the children using the "Dietary Recall" method, but from data collected from the teachers we know that the meals consumed at school try to include carbohydrates with beans and pulses.

In Need Home School

In the sub sample of 69 children interviewed for family data, only 27.5% had fathers living in the household, while the 72.5% of the fathers were dead or absent. The presence of the mothers was higher, since the 58.8% of them lived with their children. The 39.1% of the children were orphans of both father and mother.

From analysis of the data collected in the 26 "Daily Dietary Recall" interviews, we have learned that most of the children (80.8%) had a breakfast the day before, 3 children just had tea in the morning, 2 had not breakfast. One child declared to have had breakfast with a soda. Most of the declared breakfasts however, had been consumed at school before the first lesson. The 73% of the children had lunch, in most cases consumed at school. Only the 53.8% of the children had dinner at home. No children had consumed meat nor fish the day before, the only protein intake was from beans and pulses consumed mainly with posho and rise. However, we want to emphasize that, despite the results obtained with the data collected, we know that INH has a weekly schedule of meals (breakfasts and lunches) that include pulses, beans daily and meat one a week.

Marengoni Primary School

From the analysis of the family data collected from the 139 children interviewed we have recorded a very high presence of fathers and mothers in the households (99.2% each). The mean number of siblings was 5.5 (s.d = 2.3), and the higher number of siblings reported for a family was 16. Most of the children (87.9%) had three meals the day before, and four children had not breakfast. Only two children (6.1%) had eaten meat during the previous day, and 3 children (9.1%) had eaten fish. Five children (15.2%) had consumed vegetables, none of them had eaten some fruits. The most common meals for breakfast were cassava, matoke and posho (27.3%, 21.1% and 18.2% respectively). Most of the children (87.9%) had some proteins during the lunch, and also during the dinner the use of beans and pulses was very frequent (66.7%). In Marengoni school particular attention is paid in the preparations of the meals offered during the week, since teachers try to complete the main foods rich in carbohydrates (matoke, posho) by adding beans and pulses.

Gossace Primary School

In this case, we couldn't collect information neither for family data nor for dietary habits at home. However, since most of the children measured were boarding, thus they permanently lived in the school, the influence of these data on their nutritional status is weaker. Also in this school great attention is devoted to the quality of food consumed by the students with the daily use of beans with posho and weekly portions of chicken and potatoes. Moreover, Gossace school includes a quite large extension of fields previously cultivated with corn only, but where in the last two years several edible plants (some of them rich in proteins) are cultivated and used for preparing the student's meals.

General medical and orthodontic assessment of the In Need Home students

All the 141 children measured in INH school have undergone medical examinations. From the analysis of data collected it can be noted that children were in general good health, but some of them suffered the medical problems summarized in the following: cutaneous problems (23.2%), especially old skin infections and scars; abdominal region problems (48.6 %), especially distension, pain, umbilical hernia, maybe related to parasitic infection; one case of splenomegaly; heart (2.8 %), especially tachycardia and presence of bruits; lungs problems (5 %), mainly cough, and 1 child with crackles. Teeth: none on the children had important problems, however decays, erosions and orthodontic problems were quite frequent (44.8%).

Assessment of the nutritional status

Malnutrition prevalences calculated using attributed ages in all the four schools, considering the two genders and the different age classes, are sown in Table 3.6.

Bootstrap analysis showed that the prevalences of malnutrition calculated with the three different ages (Table 3.7) was similar for underweight and wasting (based on BAZ), but overstimated for stunting. In fact, the mean prevalences calculated both using the age declared or attributed showed a significant probability (p=0.005, p=0.012, respectively) to be higher (about 6%) than the value calculated with bootstrap (Figure 3.18).

Table 3.6 Malnutrition prevalences using attributed ages and considering gender, age classes, and school differences

	HAZ<-2 %	WAZ<-2 (%)	WHZ<-2 %	BAZ<-2 %	WHZ>2 %	BAZ>2 %
Total sample	12.7	5.8	1.1	3.3	1.8	0.7
Males	12.3	3.1	0.0	4.0	2.3	0.8
Females	13.0	8.1	2.1	2.7	1.4	0.7
Age class 1	8.5	6.7	0.0	0.0	4.1	4.3
Age class 2	9.9	4.1	0.0	0.0	0.1	1.2
Age class 3	13.5	6.7	2.9	4.1	0.1	0.3
Age class 4	11.7	6.2	5.0	4.9	0.0	0.4
Gossace	13.1	3.3	0.0	5.6	3.1	0.5
Marengoni	14.7	7.1	0.0	1.3	0.0	0.0
Parent's	9.7	7.8	1.0	3.1	2.0	1.2
In Need Home (INH)	14.3	7.8	4.1	4.0	4.1	1.6

Table 3.7 Malnutrition summary statistics calculated, for each index with the three types of age data

	Age declared	Age attributed	Age bootstrap
HAZ			
Mean	-0.67	-0.70	-
s.d.	1.2	1.2	-
<-2 (%)	11.9	12.4	6.4
<-3 (%)	1.4	1.4	0
WAZ			
Mean	-0.43	-0.48	-
s.d.	1	1	-
<-2 (%)	5.4	5.8	5.5
<-3 (%)	0.3	0.2	0
>2	2.2	1.9	3.8
BAZ			
Mean	-0.43	-0.40	-
s.d.	0.89	0.88	-
<-2 (%)	-3.7	3.3	2.1

<-3 (%)	0.7	0.6	0
> 3 (%)	0.7	0.7	2.5
WHZ			
Mean	-0.13	-0.13	-
s.d.	0.89	0.89	-
<-2 (%)	1.1	1.1	0.4
<-3 (%)	0	0	0

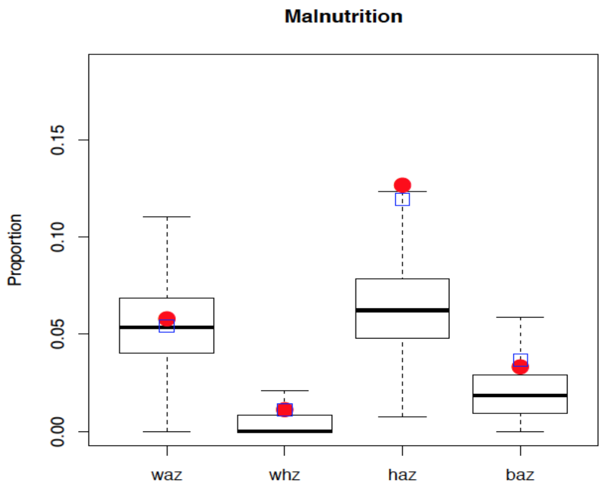


Figure 3.18 Prevalence of malnutrition (undernutrition) calculated with bootstrap analysis (box-plots) and based on age attributed (red dots) or age declared (blue squares)

The prevalence of severe malnutrition calculated with declared or attributed ages appears significantly higher (stunting: 1.4%; wasting: WHZ 0.2%, Baz 0.6%) than that calculated with bootstrap (near 0 in all cases) (Figure 3.19). On the contrary, a quite significantly lower prevalence ($p \approx 0.05$) of overweight was detected with respect to bootstrap analysis (Figure 3.20).

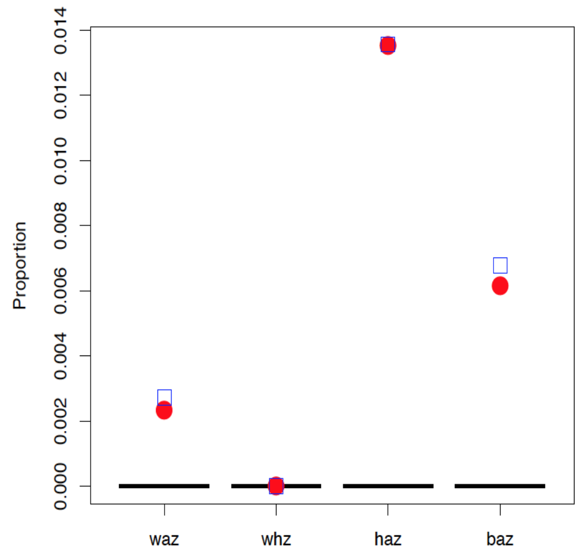


Figure 3.19 Prevalence of severe malnutrition calculated with bootstrap analysis (box-plots) and based on age attributed (red) or age declared (blue).

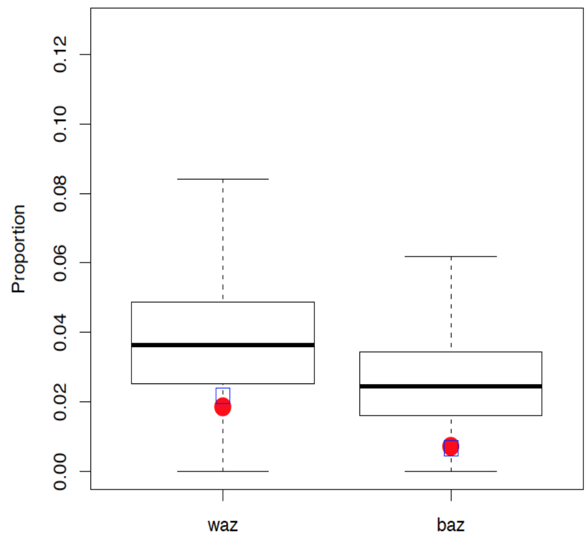


Figure 3.20. Prevalence of overweight calculated with bootstrap analysis (box-plots) and based on age attributed (red) or age declared (blue).

Age distribution was different in the four school examined (X-squared = 130.1, p-value ≈ 0.000), thus the boostrap analysis of malnutrition differences among schools was performed considering age variability.

Significant differences have been observed in the conditional distributions of malnutrition prevalence with respect to gender, age classes, and schools (Table 3.6). In particular, females showed a higher prevalences of stunting and thinness (based on BAZ) (Figure 3.21), while overweight was similarly distributed in the two genders. Undernutrition was more prevalent in children belonging to class 4 (the older ones) both at Gossace and, especially, at Kampala 1 (Figure 3.22), while overweight was more frequent among children from class 1 and 2 (the younger ones) in the two schools from Kampala (Figure 3.23).

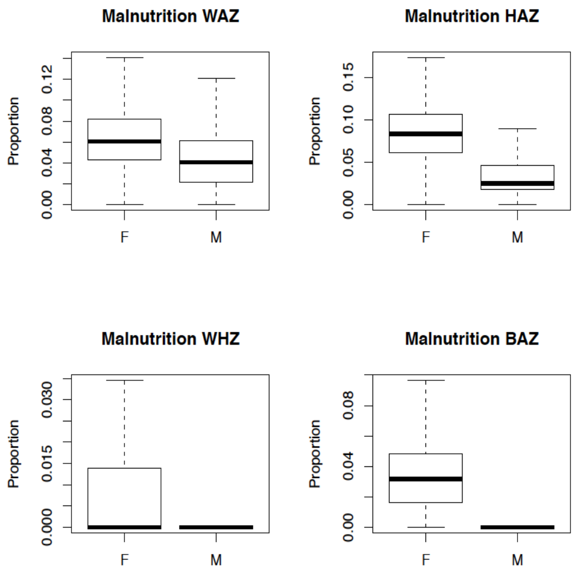


Figure 3.21 Conditional distributions of malnutrition in in females (F) and males (M).

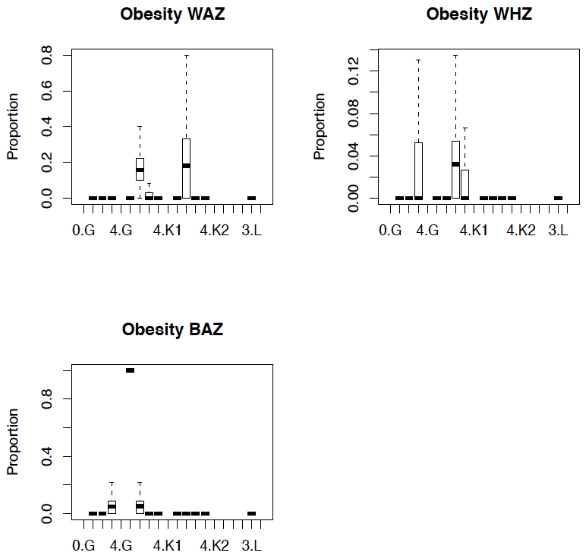


Figure 3.22 Conditional distributions of malnutrition in age classes and schools.

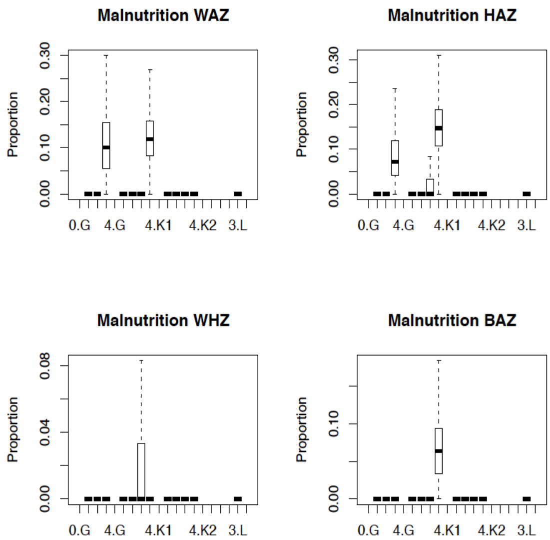


Figure 3.23 Conditional distributions of overweight in age classes and schools

The longitudinal analysis (Table 3.8) showed a general increase of WHZ ($t = 2.9$, $p = 0.005$) and BAZ ($t = 2.7$, $p = 0.007$) scores, stable values of WAZ ($t = 1.6$, $p = 0.114$), and a decrease of HAZ ($t = -5.2$, $p \approx 0.000$). The longitudinal change of HAZ scores was significantly influenced by age ($F = 4.8$; $p = 0.003$), as younger children showed a decrease of stunting whereas the older ones an increase. The longitudinal variation of WAZ and WHZ were significantly affected by the school ($F = 6.8$; $p = 0.001$; $F = 12.2$; $p \approx 0.000$; respectively). In fact, Parent's children showed an amelioration of nutritional status, while Marengoni ones an increase of wasting and underweight. WHZ also showed a significant interaction ($F = 3.7$; $p = 0.006$) between age classes and schools.

Table 3.8 Malnutrition prevalences in the total sample, according to attributed ages.

HAZ<-2		WAZ<-2 (%)		WHZ<-2		BAZ<-2		WHZ>2		BAZ>2	
2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
15.2	17.5	7.9	4.4	3.4	0	4.8	3.0	0	0	0	0

In collaboration with the schools and Bhalobasa onlus, we have organized meetings with the families where problems ono child malnutrition (both under- and overnutrition) and how it influences a proper physical and cognitive growth and hence the future of the children, have been discussed. During these meetings we have showed explicative posters and distributed a booklet on the main, but simple, daily habits that may contribute to fight child malnutrition (Comandini et al., 2014). For further detail see Chapter 4.2.

Discussion

The information on age of children analysed in this research was affected by systematic and random error. In fact, despite the attention we took to collect age data, the final sample was affected by an unintentional selection bias due to the lack or incorrect date of birth, and we have been forced to exclude 225 children (21.3%) from the total sample. According to the results of Chapter 2.2 and Comandini et al. (2016), such exclusion of children without information on age likely determined a consequent bias in malnutrition prevalence, precisely underestimation of undernutrition. Moreover, for most children with age data, we have detected high levels of age incertitude that can lead to errors in the evaluation of malnutrition prevalence, with a slight overestimation of undernutrition (Chapter 2.2; Comandini et al., 2016). As shown in more details elsewhere (Chapter 2.3; Comandini et al., 2017), the mean range of age from two different sources was equal to 7.5 (± 8.8) months. However, we have used the information on age imprecision, considering statistically the multiple information on date of birth, to analyse and overcome the effect of age error on malnutrition prevalences. Consistently with previous results obtained using DHS datasets from Swaziland (Chapter 2.2; Comandini et al., 2016), we have detected that wasting is not significantly affected by age imprecision and stunting is overestimated in Ugandan children. Contrary to our previous results, however, underweight prevalences are not significantly influenced by age imprecision. The effect on overweight, not previously investigated, is opposite, i.e. the prevalences result underestimated due to age imprecision.

On the basis of attributed ages, we found that children from higher age classes display the higher prevalence of undernutrition, especially of stunting, and the lower prevalence of overnutrition. We have also observed differences among schools, with the worst conditions in means among children from Marengoni and In Need Home schools. However, when analysed by bootstrap approach, considering the conditional distributions of malnutrition with respect to age classes and schools, a different scenario appears: significantly higher levels of undernutrition are perceivable only in higher age children from Gossace and Parent's schools. This indicates and confirms the relation between nutritional status and age class, which is in our case study more relevant than the variability due to geographic and socio-economic characteristics. We have also noticed a better nutritional status in males than in females (limited to stunting and thinness), which resulted to be significant in the bootstrap analysis. This result is contrast with the Ugandan national data (UDHS, 2012) which reported, although considering children under five only, a slightly but worst nutritional status of males.

The longitudinal analysis showed a general increase of stunting, stable values of underweight, and a decrease of wasting. Again, the effect of age on stunting prevalence was significant, with older children showing the more pronounced worsening. The longitudinal change of WAZ and WHZ were significantly affected by the school; in fact, Parent's children showed an amelioration of nutritional status, while Marengoni ones an increase of wasting and underweight.

These results are quite encouraging and give evidence that the awareness action to families on the importance on nutrition for a proper child growth, and the efforts of all the teachers to improve nutritional status are yielding benefits. In fact, for wasting and underweight, we have observed an amelioration in most of the schools. The only school where a worsening of children nutritional status has been observed is Marengoni. However, in Nakaseke District, several floods occurred, in winter 2014-2015, which have destroyed many crops thus generating a food emergency. Stunting, on the contrary, is generally worsened, but, as previously reported, this is the indicator more difficult to be recovered.

Despite this slight, albeit clear, improvement of children nutritional status, undernutrition persists in all the schools and it indicates that the food consumed by children is not completely adequate yet, especially in terms of food quality (rich in proteins and vitamins). Also for this reason, we confirm the necessity to continue with the awareness actions that need time to achieve important and lasting results.

The comparison of the results of this research with the official national statistics on malnutrition (UDHS, 2012) is not completely appropriate because of the different age range of children examined (5-16 years in our samples vs. 0-5 years in UDHS) and the different period of the survey (2014-15 vs. 2011). In general, most of the research on child nutritional status in Uganda is based on under five children (e.g., Biondi et al., 2011; Turi et al., 2013; Habaasa, 2015; Ickes et al., 2015; Agaba et al., 2016; Gray et al., 2008; Olwedo et al., 2008; Kikafunda and Tomwine, 2006; Wamani, 2006). Other researches are focused on children malnutrition and interventions to improve mothers and child-feeding practices (e.g., Ickes et al., 2012; Nankumbi and Mullira, 2015; Salaam et al., 2015).

Although rough, the comparison with national data may provide some information, especially if done at the district level. Globally, children in the four schools investigated have a definitely better nutritional status with respect to the children analysed in the last Uganda DHS (UDHS, 2012) (Table 3.9; Figure 3.24). This may be due both to the relatively better conditions of these children and to the lack, in our sample, of the influence of regions affected by recent famine, such as Karamoja region.

Ugandan children from Kampala District have a better nutritional status than the national ones, and the prevalences obtained in our schools located in Kampala (Parent's and In Need Home) are quite similar to those of the DHS children of Kampala District. In Particular, Parent's students are less frequently undernourished or with overweight, while slightly worst seems the nutritional status of INH school students that although experiencing a good quality of life at school, still live in one of the largest slims in Kampala.

Table 3.9 Prevalences of malnutrition in our samples and in national and district surveys

	Stunting (%)	Underweight (%)	Overweight (%)
Uganda	**33.4**	**13.8**	**0.7**
Total sample	12.7	5.8	0.7
Kampala District	**13.5**	**5.7**	**3.7**
Parent's School	9.7	7.8	1.2
INH School	14.3	7.8	1.6
Central 2 District	**36.1**	**11.4**	**1.2**
Marengoni	14.7	1.3	0.0
Gossace	13.1	5.6	0.5

As for the rural schools of Marengoni and Gossace, their students have a better nutritional status, for most of the indicators, with respect to the children of Central 2 District. This is not surprising if we consider that these students spend most of their time at school (in the case of Gossace most of them live at school), in a very protected environment, with teachers that take care of them and of the way they feed.

Researches on the nutritional status of the general population of children older than five years are scanty and mostly referred to particular situations, such as adolescents living in children's homes and the conditions of food and health in their houses (Vogt et al., 2016); the relationship between malnutrition and cognition (Bangirana et al., 2009); the differences between HIV-negative and HIV-positive children living in rural villages (Nalwoga et al. 2010).

Compared to children 0-12 years living in rural area with high HIV prevalence (Nalwoga et al., 2010), the nutritional status of our students appears to be better for all the indices considered. However, the cross-sectional survey published by Nalwoga et al. (2010) has been conducted about ten years before our survey, when also the prevalence of Ugandan children undernutrition was much higher than now.

A research on overweight and obesity in 12-15 year adolescents in Uganda and Ghana (Peltzer and Pengpid, 2011) reports prevalence of obesity of 10.4% among girls and 3.2% among boys, and 0.9% and 0.5% obesity among girls and boys, respectively, which are very higher with respect to the ones we have observed in our samples of students of the same age.

In synthesis, our results and literature data show that malnutrition is widespread in Uganda. However, undernutrition is generally declining. On the other side, overweight and obesity are on the rise and in fact they have been started to be recorded in DHS data only from 2011 (UDHS, 2012).

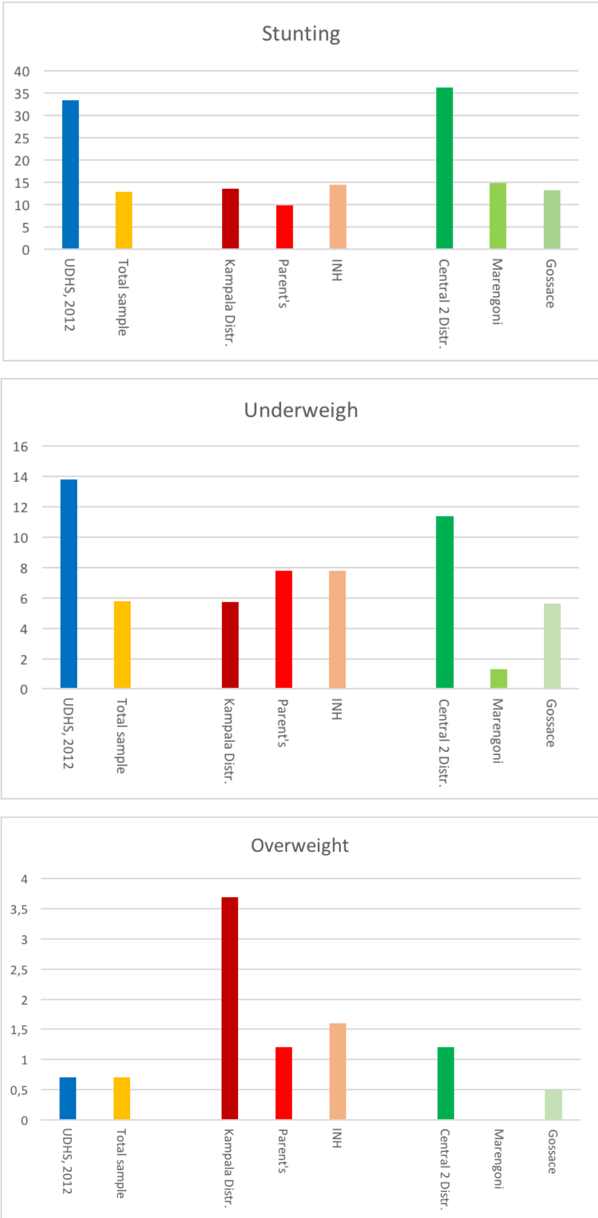


Figure 3.24 Comparison of malnutrition prevalences

The historical trend for the total Uganda retrieved from DHS provides evidence on the drivers of malnutrition among infants during the period 2001 – 2011 (Figure 3.25).

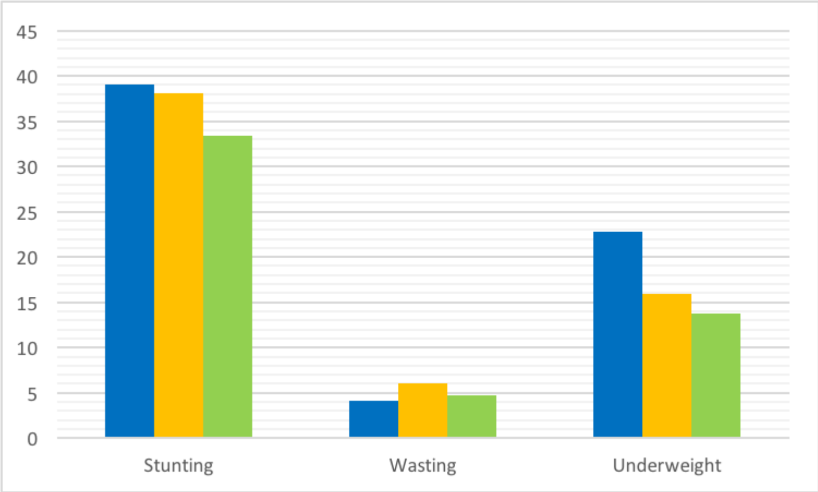


Figure 3.25 Historical trend of malnutrition prevalences of the different indices retrieved from Uganda Demographic and Health Surveys. Blue = UDHS 2001-2002; Orange = UDHS 2006; Green = UDHS 2012. Overweight has not been considered because data started to be reported only since UDHS 2012

An interesting analysis of the mutation of some socio-economic factors in Uganda in relation to the improvement of child nutritional status in the period 1996-2006 helps to better understand this process (Ssewanyana and Kasirye, 2012b). The main determinant of Ugandan children undernutrition is maternal education, whose impact is much more important than even household income and wealth status. In particular, the impact on anthropometric scores of completing secondary schooling is generally more than double than the impact of completing primary schooling.

In spite of the general improvement of child nutritional status, the overall inequalities are worsening over time, with high concentration of undernutrition among children in poor households. It means that the progresses in welfare status and the increase in public spending on health have not still be able to reduce inequalities in Uganda (Ssewana and Kasirye, 2012b). The government emphasis on Universal Secondary Education goes surely in the right direction, especially if the girls in poorest households can benefit of it, and can compensate this problem. Addressing inequalities represents another key pillar in order to achieve significant results also in the fight against all children-malnutrition in Uganda.

3.5 CONCLUSION

The analysis of nutritional status of the students from the Ugandan and Tanzanian schools analysed and monitored during this PhD program allowed to highlight and interpret the role of similarities and differences. In particular, we have collected and analysed data that permitted to compare countries and, within countries, differences related to gender, age class, environmental and social characteristics, longitudinal changes, and knowledge of birth data.

For Tanzanian children, living in Bumbire island, we have surveyed a good knowledge of their dates of birth, thus allowing us to assess their nutritional status with a good degree of reliability. They present high levels of undernutrition, which are, however, better than those reported in the national statistics on under five children realized in 2011. Also for overweight, Bumbire children present lower prevalence than metropolitan children of a similar age group. This brings us to consider that, despite the important health issues and limitations, due to isolation, Bumbire children live in a quite save environment and with social attentions.

All the Ugandan schools studied, on the contrary, included a high number of children without age data and also showed a high level of age incertitude for most of the children with some information. For this reason, we have considered statistically the effect of age imprecision on malnutrition prevalence. The different forms of malnutrition are differently affected by age imprecision, since stunting is overestimated, overweight underestimated, wasting and underweight are not affected. The levels of undernutrition are high in Ugandan samples too, with differences among schools, that indicate the importance of environmental and social condition on children nutritional status.

However, maybe as a result of the attention and care of all the schools in feeding their students, trying to propose them meals that can offer the best nutrient intake possible, the nutritional status of the children is generally better than that reported by national statistics in the regional district where the different schools are located.

In both countries we have detected a difference in malnutrition prevalence within age classes, with older children presenting higher undernutrition problems (especially stunting) and less overnutrition.

The 1-year longitudinal analysis has not shown important improvement of children nutritional status, except for wasting and underweight in Uganda, but even a worsening of stunting in both countries. Assuming that 1-year of observation is a time frame too short for detecting an improvement, especially for stunting whose recovering is difficult and gradual, these results anyhow indicate that children don't feed properly, especially in terms of micronutrients intake.

Awareness actions, in collaboration with the local public and religious organizations, and with the Bhalobasa NGO, have actively involved all the teachers (mainly in Uganda), nurses and many caregivers. Different are the responses obtained. In the Ugandan schools the feedback from teachers has been positive, since they have started promoting actions for improving and ameliorate the meals consumed by children at schools. However, the effects need time to be perceivable in the future, and it is necessary to continue especially with actions directed to girls and young mothers.

Also, political, social, and religious organizations can concretely act in tackling malnutrition, with efforts that should be different in Tanzania and Uganda. For example, in Bumbire the next start-up of a dispensary with a nurse, sponsored by Bhalobasa NGO, will be very helpful. Planning the future, the introduction of a protein-rich meal in the schools would effectively contribute to the challenge of improving nutritional status of Bumbire children. In Uganda, schools are moving in the right direction, and their perseverance together with the involvement of more families in all the awareness actions will probably lead to lasting results.

4. AWARENESS ACTIONS

4.1 INTRODUCTION

"*Education is a fundamental right and the basis for progress in every country. Parents need information about health and nutrition if they are to give their children the start in life they deserve. Prosperous countries depend on skilled and educated workers. The challenges of conquering poverty, combatting climate change, and achieving truly sustainable development in the coming decades compel us to work together. With partnership, leadership and wise investments in education, we can transform individual lives, national economies and our world.*" These words were pronounced by of the UN Secretary-General Ban Ki-moon during the 69th Session of the United Nation General Assembly held in September 2014. In that occasion a new booklet focused on education as pivotal for all sustainable development and success of the international targets, was released (UNESCO, 2014).

The causes of children malnutrition are complex and multifaceted, and many factors contribute to a person becoming malnourished (UNICEF, 2009; de Onis et al., 2013; International Food Policies Research Institute, 2014). However, as most of the researches carried out on this topic show, one of the most important predictive factor for children malnutrition is mother education (UNICEF, WHO, World Bank, 2013; UNESCO, 2014). Educated mothers are better informed about diseases, take preventative measures, recognize signs of illness of their children and the importance of the prompt use of the health services. They also are better aware of the nutrition needs of children during growth. Undoubtedly, mother education is strictly linked to her school level. However, sometimes also other barriers, such as the influence of culture custodians on the caregivers, or common popular beliefs, may play important roles on mothers' behaviors regarding child nutrition especially during their first months of life (Nankumbi and Muliira, 2015).

International organizations, like WHO and UNICEF, periodically publish reports on children malnutrition, with the aim of providing data and information, and sensitizing people on this important problem. Moreover, innumerable projects are carried out by NGOs, global movements, human charities, and governments projects with the purpose to make mothers, families, caregivers, and schools aware of child malnutrition, proposing and teaching them good daily habits to reduce or prevent it.

In order to allow scientific concepts, albeit simple, to be fully understood by non-experts is fundamental that the entire communication process is carefully considered. Indeed, several aspects of science might well be misunderstood by lay people, causing misconceptions difficult to eradicate. For these reasons, for a correct and effective scientific communication, easily and rapidly comprehensible by people to which it is directed, it is fundamental that any message or methods to be used is thoroughly planned. For an effective scientific communication, it is necessary to take in account the type of audience, the objective of the message and its effectiveness (Carrada, 2005). Moreover, the success of the message depends on how the public interprets and interacts with it (Mackay, 1994).

Moreover, also the accessibility of publications may represent a limiting factor for a positive communication. In this regard, during the last decade, the more frequent use of Open Access policies have provided an unprecedented opportunity, for developing countries, to have equal access to essential peblications and information that can contribute to an important growth of local researches and, at the same time, allow a wider distribution of their own researches results (Kirsop and Chan, 2005; Suber and Arunachalam, 2005; Kirsop et al., 2007).

In this frame, the awareness actions we have carried out with the collaboration with NGO Bhalobasa (www.bhalobasa.it) have represented an interesting opportunity to implement the role of education in fighting malnutrition practices in selected settings.

Bhalobasa, in fact, by supporting numerous children in their educational path lays the ground for their better future. On the other side, we have tried to tackle the problem of children malnutrition using our scientific expertise to start educational projects addressed to mothers, caregivers, teachers and nurses in both Africa and Italy.

4.2 AFRICA

The awareness/educational campaigns on child malnutrition, carried out in Uganda and Tanzania in summer 2014 and 2015, have been focused on the following activities:

- publication of the booklet "*A Better Life. Practical guidance to help fight child malnutrition*" (Comandini et al., 2014; http://veprints.unica.it/1058/);
- organization of meetings with mothers and caregivers in all the schools visited;
- education and training of teachers and nurses in collecting anthropometric data and in monitoring children growth;
- organization of one-day congress with exponents of the Ugandan schools and of the Uganda Ministry of Health.

A BETTER LIFE

The booklet has been realized with the aim of offering a simple and practical guide on the main and easy-to-put in practice, daily habits that may contribute to fight child malnutrition. It has been planned to be widely distributed, and reaching people which cannot access even the very basic medical information. At this purpose, the booklet has been published under an Open Access license.

Booklet planning and design

In planning the booklet, we have decided to select themes closely associated with child malnutrition, which could be tackled both theoretically and practically. The language used for the text has been selected to be very simple and understandable by everyone. The majority of information used to write the booklet has been taken (with permission) from publications of the most important organizations working on child malnutrition worldwide, that have decades of theoretical and practical knowledge on these issues, and important expertise on scientific communication (UNICEF, et al., 2010; WHO, 1995, WHO, 2008; WHO, 2009; UNICEF, 2013a; UNICEF 2013b; FAO, 2008). In addition, a number of others scientific publications and books have been used as valuable sources (Werner et al., 2012; AbouZahr et al., 2007), and we have combined all these informations with personal comments.

Besides the wise choice of the proper language, an effective scientific communication also relies on the pictures used to illustrate and visually explain the given topic. Pictures, in fact, help the audience to visualize the information, and are particularly important for people unable to read the text. For these reasons, most of the pictures of "*A Better Life*" have been accurately planned, studied and designed by Riccardo Faa, one of the authors, who prepared his degree thesis on this topic ("*Comunicazione scientifica e cooperazione internazionale: realizzazione e pubblicazione di un opuscolo informative sulla malnutrizione infantile*"). A few others figures, representing global prevalence of child malnutrition, have been reproduced, under permission, from a WHO publication (UNICEF et al., 2012). The typographic characters used, Georgia and Hans-Kendrick, have been selected because are particularly simple and easily readable.

Booklet content

The booklet (Figure 4.1) is divided into seven chapters, each one characterized by a specific icon and key messages that are further explained in details in the text. To each chapter, a specific color has been attributed. A Foreword and an Appendix have been also included. What follows is a list of the chapters, their icons and a summary of the specific content.

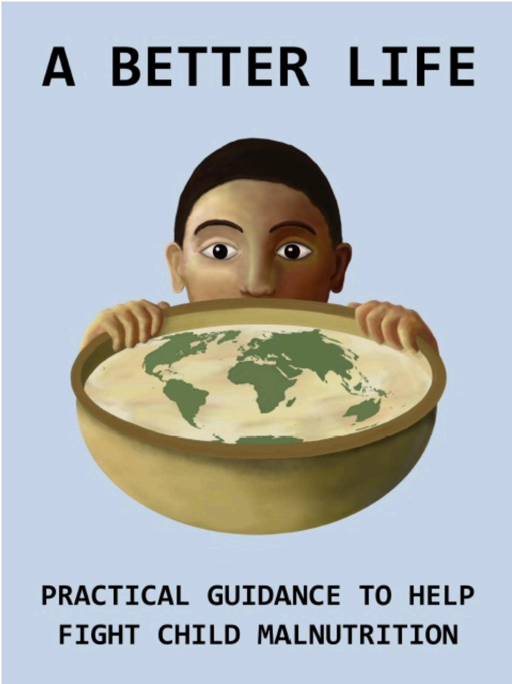


Figure 4.1 Cover of the booklet

A few words on malnutrition

In this chapter an overview on child malnutrition (considering both deficiencies and excesses of nutrient intake) is presented and discussed. Causes and prevalence in different parts of the worlds are also reported.

Breastfeedings

This is a very important issue since the way of feeding children in their very first months deeply influences their subsequent health status. We encouraged mothers to breastfeed frequently for the first six months without including other aliments or beverages, or substitutes, since milk contains the perfect balance of nutrients. We also encouraged employed mothers to continue breastfeed their children whenever they are with their babies.

Nutrition and food during child growth

The way and period for weaning of a child have an important impact in determining their nutritional status. For this reason, we suggested the basic important rules for a correct weaning in terms of food to be added to mother's milk, and quantities and number of meals to be consumed for day and for different ages. We also included a part on the main nutrients that should be part of a healthy diet and their role in body functions. We divided food in carbohydrates-, fat-, and protein-rich food and food rich in vitamins and iron, providing drawings representing the most common aliments containing such nutrients (Figure 4.2).

Figure 4.2 Common carbohydrates- rich food (a), fat-rich food (b), food rich in vitamin A (c) and rich in protein and iron (d)

The main food daily consumed by poor in the low income countries generally consist exclusively of carbohydrates, which vary depending on geographic area. Carbohydrates, alone, can't fulfill the nutrient needs of a person and, particularly, of a child. An important message we have stressed in this chapter is that the main food should also provide a variety of nutrients (proteins, vitamins, fat) other than carbohydrates and that such nutrients are present also in low cost food (Figure 4.3).

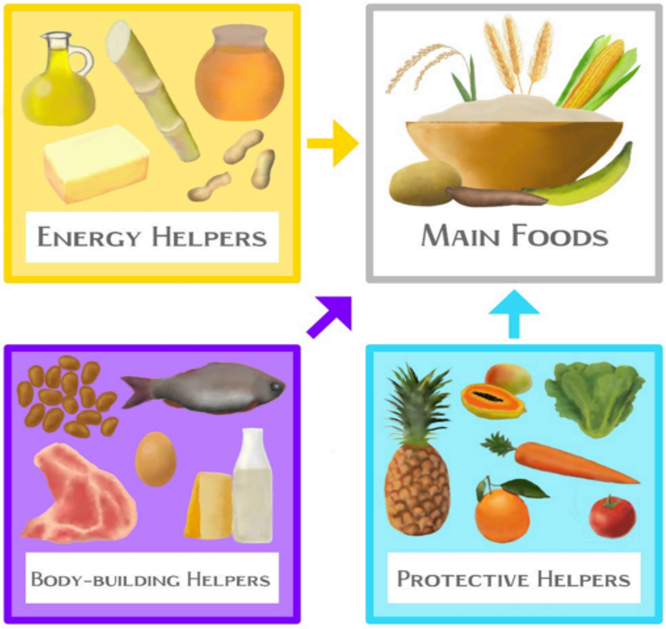


Figure 4.3 "Helper foods" to fulfill nutritional requirements can be also low-cost food such as sugar cane, pulses, fruits

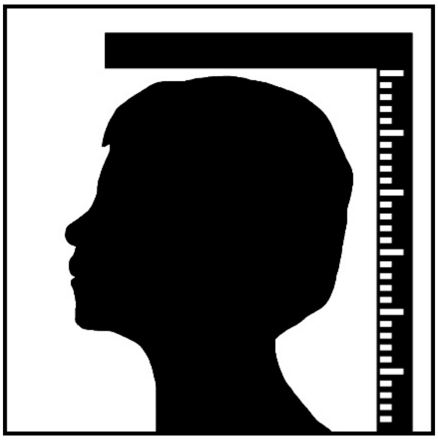
Hygienic rules for a better growth

One important reason causing malnutrition is the lack of hygiene in child environment because it can cause diarrhoeal diseases, respiratory and parasitic infections. Suggestions about the basic, simple good habits to be daily adopted by all members of the family are reported in this chapter. These include the use of soap to wash hands and face, the daily care of teeth and gums, and the use of safe or purified water for drinking. Practical information about food preparation, cooking and storing are provided, together with a focus on the importance of safe disposal of household waste.

A healthy mother

A healthy mother has more chances to give birth to a healthy baby. For this reason, it is important that she feeds properly during pregnancy and breastfeeding period, avoiding harmful substances, such as tobacco, alcohol, drugs. Each and every pregnancy deserves attention also in terms of prenatal visits, important both for mothers and babies. Also, postnatal care reduces risks of complications for the newborn as well as for the mother.

Measuring and monitoring nutritional status



This is the most technical and practical part of the booklet. Methods for assessing nutritional status are provided, explaining how to properly measure child height and weight and the instruments to be used. We have also furnished the charts, divided for sex and age, for the comparison of data collected with international reference values and for starting plotting the data useful to monitor the child growth. Moreover, we warmly recommended mothers and caregivers to regularly measure children for assessing their proper growth and, consequently, their health status.

The "right" start to a healthy life

The aim of this chapter is to sensitize people to the habit to register children at birth, because name and nationality are every child's right. Furthermore, the exact knowledge of a child age is necessary for an accurate and complete assessment of their nutritional status (see chapter 2 for further discussion on this issue). Whenever a child's birth is not registered and parents or caregivers don't know the date of birth, the child will not have the possibility to have his/her growth properly monitored and checked.

Appendix

The assessment of nutritional status implies the comparison of anthropometric values with a set of references value. The most commonly used are the WHO Child Growth Standards (http://www.who.int/childgrowth/en/) developed by the WHO Multicentre Growth Reference Study (WHO, 2006). From the reference values, specific growth charts distinguished for gender and age-classes (0-2; 2-5, and 5-19 years) have been drafted. In this part, we have included different scorecards (subdivided for gender and age-class) to be filled with the child personal data, vaccinations and health problems, and the growth charts for each anthropometric index (Figure 4.4). In our opinion, these scorecards may represent a very simple but useful tool in the hands of nurses and/or teachers for monitoring a child growth and health.

Figure 4.4 Scorecards to be filled with child's personal data, vaccinations and health problems, and growth charts for monitoring child growth

Distribution

The booklet has been printed in 1000 copies. It has been distributed to all the teachers and nurses of the schools visited, both in Uganda and Tanzania, and to all the people (staff of the Uganda Ministry of Health, priests, prelates, educators) encountered during the several meetings organized in our awareness campaign on child malnutrition. In Italy we have distributed copies of the booklet to all the main Italian associations or NGOs working with children in countries where child malnutrition occurs, and also to selected research groups at several national and international universities. An on line version of the booklet is also freely available, under Licence Creative Commons Attribution Non-commercial No Derivatives, from http://veprints.unica.it/1058/.

A dedicated Facebook page has also been created where the booklet, accessory material and comments are published (https://www.facebook.com/child.malnutrition.assessment.prevention). Bhalobasa distributed copies of *A Better Life* to their contacts in all the countries where it supports children and where projects on child malnutrition are about to start. We are planning a translation of the booklet in Luganda (the main language in Uganda) and in Bengali.

MEETINGS WITH MOTHERS AND CAREGIVERS

In all the schools where anthropometric data have been collected, particular attention has been dedicated to organize meetings with mothers and/or caregivers with the aim to talk together about child nutrition and daily habits that mothers should adopt for a healthy growth of their children. In these occasions, a didactic poster designed for a better understanding of the concepts explained has been used (Figure 4.5). Most of the mothers we met on these occasions had low or very low educational level, and some of them didn't speak English, therefore we have planned the poster in detail so to deliver an effective message, scientifically correct, yet readily understandable by all the mothers. For this reason, in some occasions, the main messages have also been translated in Luganda. The poster is mainly composed by simple and schematic drawings, and text is reduced to a minimum. Colored frames have been used in order to separate, but also highlight, the different habits to be used for fighting child malnutrition.

Figure 4.5 Poster used during meetings with mothers and caregivers for a better understanding of the basic concepts explained in the booklet *A Better Life*

Figure 4.6 Meeting families in Bumbire (Tanzania)

Figure 4.7 Mothers in Marengoni School, Luweero (Uganda)

Figure 4.8 Families of students from Parent's school, Kampala. Uganda

All the meetings were interesting occasions for a better mutual understanding (Figures 4.6, 4.7, 4.8). Most of the mothers have shown great interest in the proposed subjects and they clearly expressed their will to give their children the best possible future. They asked several questions on the concepts brought forward by the booklet and poster, but also on the research we were conducting.

TEACHERS AND NURSEYS EDUCATION/TRAINING

During the two surveys of 2014 and 2015, we have always involved teachers and nurses in collecting children's anthropometric data (Figure 4.9). We have taught them the basic rules for measuring weight, height and circumferences according to standard procedures (WHO, 2008). Then we have also shown them how to plot collected measurements in the growth charts, stressing the importance to yearly monitoring each child growth. The instruments used for data collections (anthropometer, scale and measure tape) have been donated to all the visited schools. All the teachers and nurses have participated to the events organized where workshops on children malnutrition have been proposed in order to put into practice the information provided. All people involved have shown interest, and have achieved the basic theoretical and technical skills to take and analyse anthropometric data for nutritional assessment.

a

b

Figure 4.9 Measuring with the help of nurses (a) and teachers (b)

ORGANIZATION OF ONE-DAY CONGRESS WITH EXPONENTS OF UGANDAN SCHOOLS AND UGANDA MINISTRY OF HEALTH

In August 2014, we have organized a congress entitled "Teaming up against child malnutrition", held in Kampala (Figure 4.10) to which participated all the teachers and headmasters of Ugandan schools that collaborate with Bhalobasa in the country, and also representatives of the Uganda Ministry of Health participated. On that occasion, together with oral presentations focused on child malnutrition (Figure 4.11), we organized also a practical workshop where we have trained the participants in measuring children and in analyzing collected data (Figure 4.12). We also discussed more in general how to tackle malnutrition problems. Also on this occasion there has been a positive feedback from the people involved.

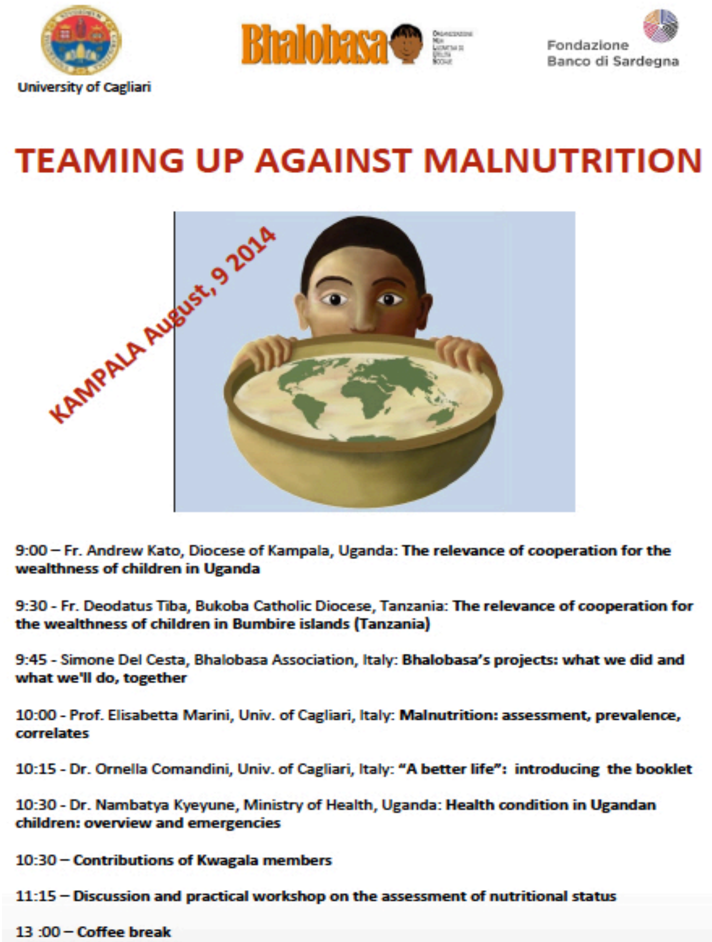


Figure 4.10 Poster conference

Figure 4.11 Some of the speakers that had a talk during the conference

Figure 4.12 Discussion within different groups during the practical workshop

4.3 ITALY

Problems related to child malnutrition in Italy are very different from those already discussed for Uganda and Tanzania, but they exist and need to be tackled. The Istituto Superiore della Sanità (http://www.iss.it/) and, in particular "OKKIO alla SALUTE", one of ISS surveillance systems on overweight and obesity of children 6-10 years, have recently provided warning data on children malnutrition (overnutrition). According to these data some 20.9% of children in Italy are overweight and 9.8% of those are obese (Istituto Superiore di Sanità, 2016). Although data are better with respect to those recorded during previous years, suggesting a positive trend toward a better health status of Italian children, problems regarding bad nutrition behaviors persist. For these reasons, we have planned meetings with the aim of making Italian children and their families aware of the importance of good daily nutrition and healthy habits, and also to increase people awareness on nutritional problems of children in a different part of the world, in our specific case Africa.

To this end, the awareness/educational campaigns on child malnutrition carried out in Italy in the past three years have been centered around the following activities:

- Organization of one-day Conference, held at the University of Cagliari;
- Realization of a Project in collaboration with Lunamatrona, a town with about 2.000 inhabitants, located in the province of Cagliari;
- Training of Bhalobasa volunteers.

ORGANIZATION OF THE CONFERENCE AT THE UNIVERSITY OF CAGLIARI

A conference titled "Ricerca e Cooperazione: esperienze africane" was organized on March 25th 2013 (Figure 4.13). It was held at the University of Cagliari and it has represented the first step of the overall project developed during this Ph.D. thesis. On that occasion, with the help of different speakers, we discussed the issue of child malnutrition, underlining the importance of synergic actions between academia, NGOs and voluntary associations in tackling this important problem.

The conference was divided in two sections, with two different types of audience: in the morning, the students (aged 8-14) from several schools of Cagliari and hinterland attended; in the evening, scientists, university students, people working on international cooperation, and politicians made the audience. Overall, we have had a very good response from most of the 300 participants present in both the sections, and hints and idea sparkling from discussions and talks during the conference have been really useful in planning most of the actions we have finalized afterwards. Articles and press releases about the conference, published on regional media, are available online (http://www.unica.it/pub/7/show.jsp?id=21918&iso=19&is=7).

Figure 4.13 Poster of the conference

REALIZATION OF THE PROJECT WITH THE TOWN OF LUNAMATRONA

On November 2014 a project, to be realized together with the town of Lunamatrona (CA), was funded by "Fondazione Banco di Sardegna" (http://www.fondazionedisardegna.it). The project, titled "Nessun uomo è un'isola: ponti intercontinentali tra la Sardegna e l'arcipelago di Bumbire (Tanzania) per interventi sulla malnutrizione infantile", was designed to be developed in several steps, both in Italy and Tanzania. In Tanzania we planned to assess the nutritional status of children living in Bumbire Island to organize meetings with parents and caregivers with the aim to talk together about child nutrition and related problems, and to train some teachers and nurses on the methods to correctly take and analyze anthropometric measurements. At the same time, we asked Tanzanian children in each of the seven classes of the primary school we visited, to write a letter, addressed to the students of Lunamatrona, about them and their personal life (Figure 4.14).

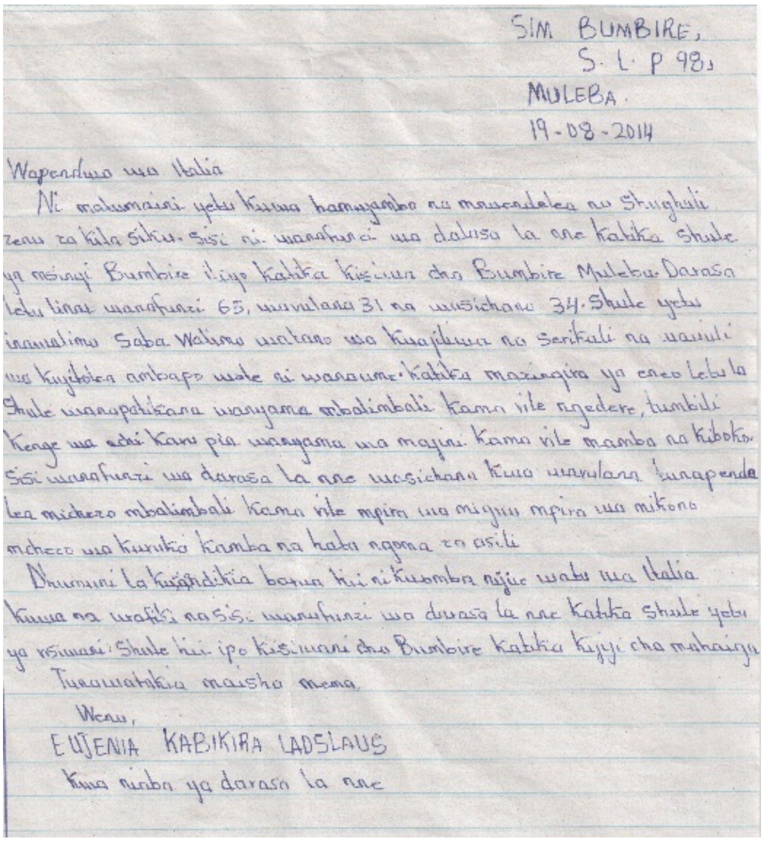
On the other side, in Italy, we met children to talk about malnutrition and its different expressions in different parts of the world, and in particular about overnutrition and its effects on children health. We focused on the causes of overweight and obesity, that affects too many children in Italy, and that are not only related to the food consumed, but also to the children style of life, which often tends to be sedentary. We have always tried to involve the Italian students in discussion during all the meetings we the aim to identify together possible solutions for tackling this problem.

Furthermore, we have planned a series of actions aimed at the entire Lunamatrona population for their better understanding of the reality of Bumbire Island and the life style of its inhabitants, so to create a sort of cultural twinning between people living in two islands in very different (both geographically and culturally) parts of the world. For this purpose, we have met people in different places: the school, the local retirement home, the social club, showing all of them several pictures from Bumbire and talking to them about this island and the people that live there (Figure 4.15). Of course the letters of Tanzanian children, together with the pictures taken during our visits in Bumbire, were also showed and discussed.

The following step of the project was to involve all Lunamatrona population in preparing something we could bring as a gift to children in Bumbire during our next visit to the island. After some discussion, it was decided to craft a simple school bag for each of the 300 students in Bumbire for carrying books and other school stuff. These bags were cut and sewed by several women (included those in the retirement home) and then decorated by the children (Figure 4.16).

Moreover, the teachers of Lunamatrona primary school involved in the project dedicated part of their didactic program to delving into the study of Africa and Tanzania and in preparing a video on Sardinia in general and

Lunamatrona in particular to be shown to their Tanzanian friends. In the video, all the children introduced themselves in English and talked about their life in Sardinia.


SIM BUMBIRE,
S. L. P 98,
MULEBA.
19-08-2014

Wapendwa wa Italia
Ni matumaini yetu kuwa hamjambo na mnaendelea na shughuli
zenu za kila siku. Sisi ni wanafunzi wa darasa la nne katika shule
ya msingi Bumbire iliyo katika kisiwa cha Bumbire Muleba. Darasa
letu lina wanafunzi 65, wavulana 31 na wasichana 34. Shule yetu
inawalimu saba. Walimu watano wa kuajiriwa na serikali na wawili
wa kujitolea ambapo wote ni wanaume. Katika mazingira ya eneo letu la
shule wanapatikana wanyama mbalimbali kama vile ngedere, tumbili
kenge wa adi kani pia wanyama wa majini kama vile mamba na kiboko.
Sisi wanafunzi wa darasa la nne wasichana kwa wavulana tunapenda
kwa michezo mbalimbali kama vile mpira wa miguu mpira wa mikono
mchezo wa kuruka kamba na hata ngoma za asili
Dhumuni la kuwaandikia barua hii ni kuomba nijue wabu wa Italia
kuwa na urafiki na sisi wanafunzi wa darasa la nne katika shule yetu
ya msingi. Shule hii ipo kisiwani cha Bumbire katika kijiji cha mahainga
Tunawatakia maisha mema,
Wenu,
EUJENIA KABIKIRA LADSLAUS
Kwa niaba ya darasa la nne

Figure 4.14 One of the letters sent to Italian children from children living in Bumbire

Figure 4.15 Meeting people in Lunamatrona

Figure 4.16 Different moments of bags preparation in Lunamatrona

We firmly believe that all these actions, and those carried out with children at school in particular, have had an important impact in understanding differences and similarities among Italian and African populations. We are confident that children, thanks to the 'virtual' friendship with children of Bumbire, gained awareness on the importance of nutrition, good health and the good habits that contribute to make a child a healthy adult, and the different expression of these concepts in different parts of the world.

During our subsequent visit at Bumbire island, in July 2015, we delivered the 300 bags to all the children (Figure 4.17) and we showed them and their families the video prepared by Lunamatrona children and the many pictures they also sent (Figure 4.18). The response by Bumbire people was even better than we expected. Both children and adults showed great curiosity and interest about Lunamatrona, Sardinia and Italy, indeed.

Figure 4.17 Children in Bumbire island showing off their new bags!

This project with Lunamatrona ended in November 2015 with the organization of two conferences, one in Lunamatrona and the other one in Cagliari (Figure 4.19). The conference in Lunamatrona was open to the entire population and was an important opportunity for examining and discussing all the steps of our project: all those that had a role in it (including school children) were able to talk about their experience and the way they were involved. The other conference was held in the lecture hall of the University of Cagliari and classes from several schools of Cagliari and hinterland were present. Also in this occasion we presented the project with the words and pictures of some of the Italian people involved.

Figure 4.18 Children in Bumbire island watching the video prepared by their friends from Lunamatrona

Also during these occasions our first aim was to stress the role of education in fighting malnutrition, trying to reach a balance between the rigorous scientific approach to the different topics we discussed and the public understanding of the underlying human and social aspects, with a more emotional touch.

Figure 4.19 Poster of the conference held in the lecture hall of the University of Cagliari, on November 2015

TRAINING OF BHALOBASA VOLUNTEERS

One of the basic points of all the awareness actions we have carried out on problems related to children malnutrition, its causes, the consequences and the ways to prevent it, was to make people able to act consciously and independently. For this reason, throughout our project, we have always involved African nurses and teachers, parents and caregivers. However, to make this approach more effective and potentially expandable to others geographic areas where the problem of child malnutrition is present, it seemed necessary to involve also all the Bhalobasa volunteers who frequently visit a range of developing countries were they support public health projects and children education. For this reason, on November 15th 2014, we have organized a meeting in Perignano (Pisa) where, together with providing general and basic information about children malnutrition, we presented our project in Uganda and Tanzania and the booklet "*A Better Life*". In the second part of the meeting we have organized a short practical course on collecting and analyzing anthropometric data, more particularly addressed to those ones with medicine and nursing education. Participants were then divided in working groups, and hypothetical situations of children malnutrition were proposed and the groups were asked to deal with them properly (Figure 4.20).

In this way, we hope to have started a positive feedback loop, with every new mission organized by Bhalobasa addressing the importance of tackling children malnutrition in a growing number of settings.

Figure 4.20 Different moments during the conference held at Perignano, Pisa, with Bhalobasa volunteers

5. CONCLUSIONS

Malnutrition is a social and health problem that still affects millions of children worldwide. With its two different faces – undernutrition and overnutrition – child malnutrition is the result of several determinants, the most important of which are the lack/surplus of adequate food, life-style, mother's low education, socio-economic situation of families. For this reason, any research on the nutritional status of a young population must be carried out applying a wide approach, that should include, together with proper scientific and technical expertise, also the careful observation of the environment and the deep knowledge of socio-political aspects of the locality investigated. This is particularly important in areas such as many African countries, where natural disasters and socio-political changes, and instability deeply affect the quality of people's lives. Moreover, for a concrete use of all the data collected and the adoption of adequate policies, an active collaboration with local groups, such as research centers, schools, associations etc., it's fundamental. In our case, this has been possible thanks to a fruitful collaboration with Bhalobasa NGO, that joined us in this project, also allowing us to settle long-lasting contacts with the schools with which we have worked.

In this PhD project we have tried to approach the study of the assessment of nutritional status of the youth population in some schools in Uganda and Tanzania taking into proper consideration some factors that could either determine and interact with the results.

In particular, we have:

- studied in detail the influence and impact of the lack or imprecision of birth data on children nutritional assessment. This because most of the indices for nutritional assessment are strictly connected with the knowledge of the precise age of children and because in many sub-Saharan African countries children are often not registered at birth, nor the date of birth is remembered. We have approached this issue from a theoretical point of view, considering all the sub-Saharan African countries, but also analyzing real data, i.e. our sample of Ugandan and Tanzanian children;

- we have assessed the nutritional status of schooling children in five schools (four in Uganda, one in Tanzania), characterized by different social and environmental elements. We have studied the different prevalence in relation to gender and age class, the influence of different social and cultural settings on children malnutrition, and also the influence of uncertainness of birth data in malnutrition prevalence;

- we have involved teachers and nurses in measuring, plotting and assessing the nutritional status of their students. The idea at the basis of this is the promotion of a sort of simple ‘school health care plan’ similar to the one present in Italy until the ’70, where experts (mainly nurses) supported the teachers in evaluating the correct growth of the children and promoted the basic health habits and vaccinations. For this reason, we have supplied all the schools we visited with a simple pediatric booklet where the growth of every student could be plotted yearly. Further, in each school we have pointed out to the supervisors the names of all the children resulted to be undernourished from the analysis of the data collected. In this way, it will be possible to intervene promptly to improve/ameliorate food intake for these children and to understand the reasons of undernutrition. We have also worked directly with families, waging awareness campaigns on the importance of a proper child’s growth for their better future. In meeting caregivers, we have always tried to understand their daily situations, so to propose them actions or behaviors that could be feasible and effective;

- we have also promoted awareness actions in Italy, involving students from Sardinian schools and Universities, the inhabitants of an Italian town, Lunamatrona (CA), with whom we have accomplished a specific project, Bhalobasa volunteers, and people interested in international cooperation.

Considering all the actions carried out, these are, in summary, the main results obtained.

THE LACK OF BIRTH DATA

Before this Ph.D. project started, during the first visit of UNICA researchers to Ugandan schools in 2012, it was noticed that for many students their date of birth was hardly knew, for most of them being roughly known their age in term of number of years only. Also, data collected by social workers, teachers or entries in school registers were quite superficial since they mostly reported child age in years, rather than recording full birth date. This situation, unknown to our team before that time, was quite worrying, since knowledge of the exact age of children is crucial for a confident use of nutritional indices based on age (HAZ, WAZ, and BAZ). The lack of birth data could have thus strongly hampered our research. For this reason, we studied in detail this phenomenon in Uganda and Tanzania, and then compared our data with what known for sub-Saharan Africa in general, striving to measure its impact on malnutrition prevalence as reported in the literature.

Using datasets collected in MICS and DHS surveys in several sub-Saharan African countries, we have noticed an selection bias in favour of registered children and children with a valid and complete date of birth, which led to underestimating undernutrition prevalence. Moreover, information bias and errors, that more likely affect unregistered children, contribute to expanding the underestimation of undernutrition even further. Both bias and random error can produce a significant variation in the prevalence of malnutrition, a variation that decreases with child age. For these reasons, we have stressed the need to continue promoting birth registration, paying particular attention to the quality of children birth data during all the researchers on nutritional assessment. This is the only way information on child malnutrition can be considered reliable.

Analyzing age data quality of children in the five schools surveyed, it emerged that while in Bumbire (Tanzania) a good knowledge of child age is available (about 95% of children have complete and quite accurate age data), information on age was available only for 79.8% of Ugandan children, and for 39% of those only the year of birth was given. Moreover, for some of the Ugandan children we collected information on age from different sources, and even for children with a complete date we have observed a high uncertainty degree. The mean gap between ages from two different sources was 7.5 (±8.8) months, and the maximum was 3 years and 3 months.

Indeed, despite our efforts in trying to estimate and limit the effects of age error on malnutrition prevalence, also our samples have been affected by an unintentional selection bias, since we have been forced to exclude some 16.6% of the total children measured (250 out of 1504) because of the lack of their birth data. However, we have considered the effect of age imprecision on malnutrition prevalence in assessing nutritional status of Ugandan children.

ASSESSMENT OF NUTRITIONAL STATUS

We have collected personal and anthropometric data of 1504 children (448 in Tanzania and 1056 in Uganda), and for 1254 children (423 in Tanzania and 831 in Uganda) we have assessed their nutritional status. Moreover, for a subsample of children, data on family structure and educational level, and children alimentary habits have been collected. The five schools surveyed presented social, cultural and environmental differences, hence permitting us to compare countries and, within countries, the effect related to gender, age class, and socio-economic characteristics.

The accurate age data of most of the children from Bumbire allowed the reliable use of the nutritional indices. Bumbire children showed high levels of undernutrition (stunting = 31%; underweight = 13%) which are however lower that than those reported in the national statistics for under five children as compiled in 2011 by DHS. Overnutrition, a problem on the rise for children living in developing countries, and also in metropolitan Tanzanian children, is absent in Bumbire pre-adolescents. Considering results obtained, we can affirm that, despite limitations due to insular conditions, children in Bumbire live in a quite protected environment from the point of view of social conditions, as indicated also by the better knowledge of their date of birth.

Information on age data collected in Uganda schools was quite incomplete or inconsistent. In fact, less than 80% of children had some age information, and a detailed analysis on data quality showed the weakness of these information. For these reasons malnutrition prevalence has been calculated considering statistically the effect of age imprecision. The various forms of malnutrition are differently affected by age imprecision, since stunting is overestimated and overweight is underestimated, while wasting and underweight are not affected at all. The levels of undernutrition are high in Ugandan schools (stunting = 13%; underweight = 6%), but low with respect to the national data for under five children (as evaluated by DHS in 2011). Also, if we consider national data for the districts where the schools are located, we can detect a generally better nutritional status for our children. Differences among schools have also been observed, thus suggesting the impact of environmental and social conditions on children nutritional status. Where nutritional status is better, this might be also the result of the attention and care of those working in selected Ugandan schools, trying to offer their students meals providing the best nutrient intake possible.

In both Tanzania and Uganda, we have detected differences in malnutrition prevalence within age classes, with older children presenting higher undernutrition problems (especially stunting) and less overnutrition.

In both countries, the 1-year longitudinal analysis showed a quite stable level of most of the nutritional indices in Tanzania, a reduction of wasting and underweight prevalence in Uganda, and a worsening of stunting in both countries. We are aware that 1-year of observation is a frame of time not sufficient to appreciate a decrease of stunting, which is difficult to be recovered. We are confident that the awareness actions on the importance of nutrition for a proper child growth are starting to change people’s attitude toward the issues at stake. More evident effects will need time to be perceivable, and to get there it is of paramount importance to put much effort in actions especially directed to girls and young mothers. Planning the near future in practical terms, the introduction of a protein-rich meal in the schools would effectively contribute to improving nutritional status of Bumbire children. In Uganda, schools are moving in the right direction, and their perseverance, together with the involvement of more families in the awareness actions, will probably lead to lasting results.

AWARENESS

During the surveys completed both in Tanzania and Uganda, we have waged awareness and educational campaigns on child malnutrition in all the schools and villages visited. We mainly focused our actions on the education and training of the teachers and nurses in monitoring child growth. We have also involved all the teachers in order to succeed in obtaining reliable birth dates, and we have tried to make them aware of the importance of the knowledge of the correct date of birth and birth registration for all children. We also provided the schools of technical instruments, of the booklet '*A better life'* a practical and easy-to use guide to help fighting child malnutrition, and of the didactic posters we used during the meetings for a better understanding of the concepts explained. We published an on line version of the booklet, under an Open Access license (http://veprints.unica.it/1058/).

We also organized several meetings with parents and caregivers, and profusely discussed with them about nutrition and its importance for a proper child growth, but also about the value to register children after birth. The response of people involved in these actions has been very enthusiastic, and they have all shown interest. We had the chance to verify the effectiveness of these activities during our last visit in Uganda, in summer 2016, when some teachers have shown us the growth charts that have been plotted, during the anthropometric data collections that they themselves have organized at the beginning of the new school year (Figure 5.1).

Moreover, most of the schools visited have started to create their own vegetable gardens, looked after by both the teachers and the students, for growing vegetables and pulses to be cooked for the meals consumed at school. The choose of the vegetable to be planted was, in some cases, particularly accurate, and local plants, such as Dodo plants (*Amaranthus* spp.), whose leaves are edible and the seeds are rich in proteins, have been selected for the purpose (Figure 5.2).

In all the meeting we have organized with mothers and caregivers, the response has been overwhelmingly positive. Especially mothers, have shown a keen interest in knowing how they could help their children to grow better. They asked many specific questions, and in turn we also learned a lot from them: we could spot the weak points of our interventions and what aspects were overlooked and should thus be tackled so to improve the effectiveness of our messages.

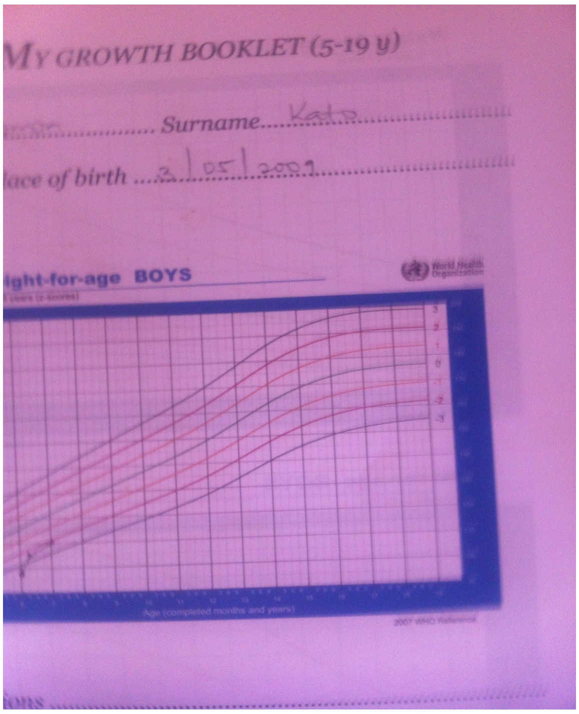


Figure 5.1 Photo of the pediatric booklet plotted by teachers in Parent's school, Uganda

Figure 5.2 Dodo plants (*Amaranthus* spp.), cultivated in Gossace school, Uganda. The seeds of Dodo can be used to prepare meals rich of proteins

All the meetings organized both in Africa and in Italy led to positive results. Besides a good attendance, we believe the main outcome was a high level of interactions between speakers and the public, either composed by adults, children, Italians or Africans, thus giving substance to all the subjects proposed.

One of the most fruitful actions we have put in motion during this research, was the training of Bhalobasa volunteers on the importance of nutritional and hygienic condition on children's proper growth. Indeed, in the next future they will be themselves able in turn to train teachers and nurses with whom they are in contact in different countries, so we will have an exponential growth of much wanted skills and expertise on issues related to children malnutrition.

This point is shown most clearly by this example. During a visit in India in 2015, Bhalobasa volunteers distributed copies of *A Better Life* to schools and social workers. Shortly after this visit, they received the feedback that the booklet and the information it carries were used and adapted to specific local situation, by one of the social workers to illustrate key points about undernutrition in some villages in West Bengal, India (Figure 5.3).

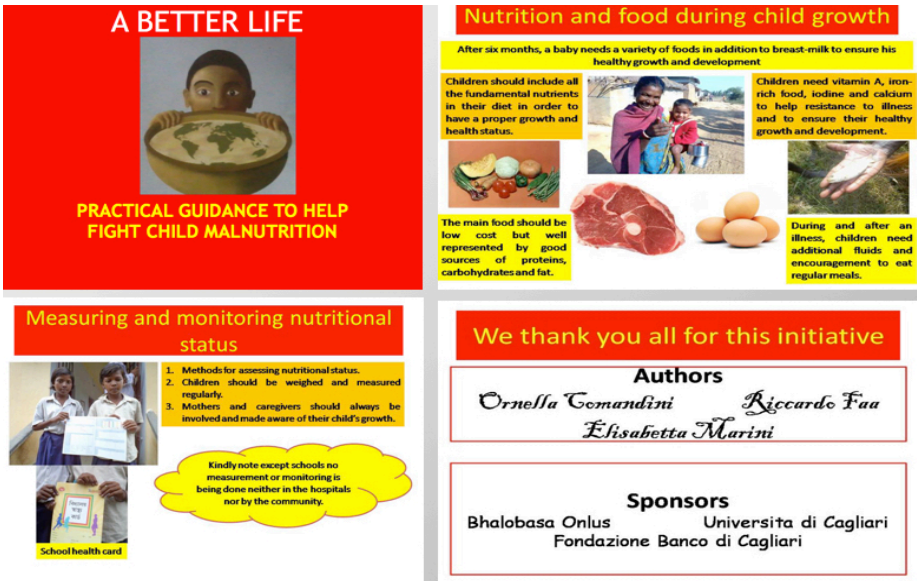


Figure 5.3 One of the slides presented by a social worker during a presentation to mothers living in some villages in West Bengal, India, using *A Better Life* as a cue to discuss children malnutrition

FUTURE EXPECTATIONS

We firmly believe in a multi-disciplinary approach in conducting research on children malnutrition, and we think that the results coming out from this work confirm our view. The very basis of any future actions lies on the 'mutualistic symbiosis' among national institutions, international cooperation and academic research, an interaction that needs to be strengthened and implemented. In this way we can currently give substance to scientific research and make sure that every result, every action, can be translated, in Tanzania, Uganda and in any other country, in a small change in the local daily habits to improve the nutritional status of children. Only if awareness actions and the monitoring of the children growth are conducted locally, within schools and by African caregivers and nurses, we can ultimately have long-term benefits. Only when full independence in designing projects and accomplishing relevant actions is achieved, we will be legitimated in considering our work as fruitful.

"*A short-term efficacious intervention may have few discernible, sustainable long-term benefits*" (Dead aid, Dambisa Moyo, 2009)

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