Spring 5-17-2013

Assessment of the Impact of the Mercy Corps Kyrgyzstan Food for Education 2010 Program

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ASSESSMENT OF THE IMPACT OF THE MERCY CORPS KYRGYZSTAN FOOD FOR EDUCATION 2010 PROGRAM

By

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Master of Public Health

GEORGIA STATE UNIVERSITY

A Thesis Submitted to the Graduate Faculty

of Georgia State University in Partial Fulfillment

of the

Requirements for the Degree

MASTER OF PUBLIC HEALTH

ATLANTA, GEORGIA 30303

2013

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Under the direction of Rodney Lyn, PhD

ABSTRACT

Background: Undernutrition is a major public health problem, contributing to 33% of deaths in infants and young children globally. Undernutrition not only impacts child health but directly and indirectly impacts education, a fact that is undoubtedly underlying the ubiquity of school-based nutrition programs worldwide. In developing countries where the majority of undernutrition occurs, resources are limited, and while school nutrition seems to make logical sense, evidence is needed to show that feeding children in schools prevents and counteracts the adverse health effects of undernutrition.

Method: This study is an evaluation of the nutritional impact of Mercy Corps Kyrgyzstan's school feeding program in pre-school children, as indicated by the nutritional outcome of stunting. In Kygryzstan, Central Asia, Mercy Corps provided 6 metric tons of rice, flour and oil as well as nutrition education to kindergartens in 40 rural regions, serving 41,000 children, for one year. Anthropometric measurements were collected at the beginning and end of the program for 60 randomly selected institutions. The WHO 2006 Growth Standards and 2007 Growth Reference were used to determine the stunting, wasting, underweight and obesity statuses of each child. The prevalence of each condition before and after the program implementation was compared. Additionally, dietary diversity scores, assessed using a simple food score questionnaire, and other characteristics of the 60 chosen kindergartens were assessed for their ability to predict whether or not a child recovered from undernutrition by follow-up.

Results: Children who were stunted, wasted and underweight at baseline, recovered by follow-up, with rates of recovery of 50%, 65% and 50%, respectively. The prevalence of stunting, wasting and underweight in the population decreased from 13.8%, 3.4% and 3.2%, respectively, to 8.6%, 2.1% and 2.3%, respectively.

Conclusion: Pre-schools present a unique opportunity to dually impact child education and health. The results of this study suggest that providing nutritious foods in school can lead to improvements in indicators of childhood nutrition, including stunting. These results are particularly significant as the dearth of research on pre-school feeding's impact on growth and nutrition has led to this particular intervention being deemed ineffective for improvement of nutritional outcome.

ACKNOWLEDGEMENTS

I would like to thank the chair of my committee, Dr. Rodney Lyn, and members of my committee Dr. Murugi Ndirangu and Sarah Connell. Thank you for providing the feedback and guidance needed to complete this thesis.

I would also like to thank my friends and family who supported me not only through this thesis but also through all of my education to this point. A tremendous thanks to my friends Stanka Sojáková, Jennifer Lind, Shameem Jabar and Barbara Yankey and to my family members Bliss Sunday-Piaro, Mary Palmer Legare, Andrew Legare and Nia Piaro. Completion of this thesis would not have been possible without the support from my church family and pastors Caroline Leach and Nibs Stroupe, who made it possible for me to complete my practicum in Kyrgyzstan.

Finally, I would like to thank the staff of the Food for Education 2010 at Mercy Corps Kyrgyzstan for their hard work and dedication to serving the people of Kyrgyzstan. I am very grateful to them for allowing me to use the data collected through their hard work in my thesis.

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CHAPTER I

INTRODUCTION

Focus of study

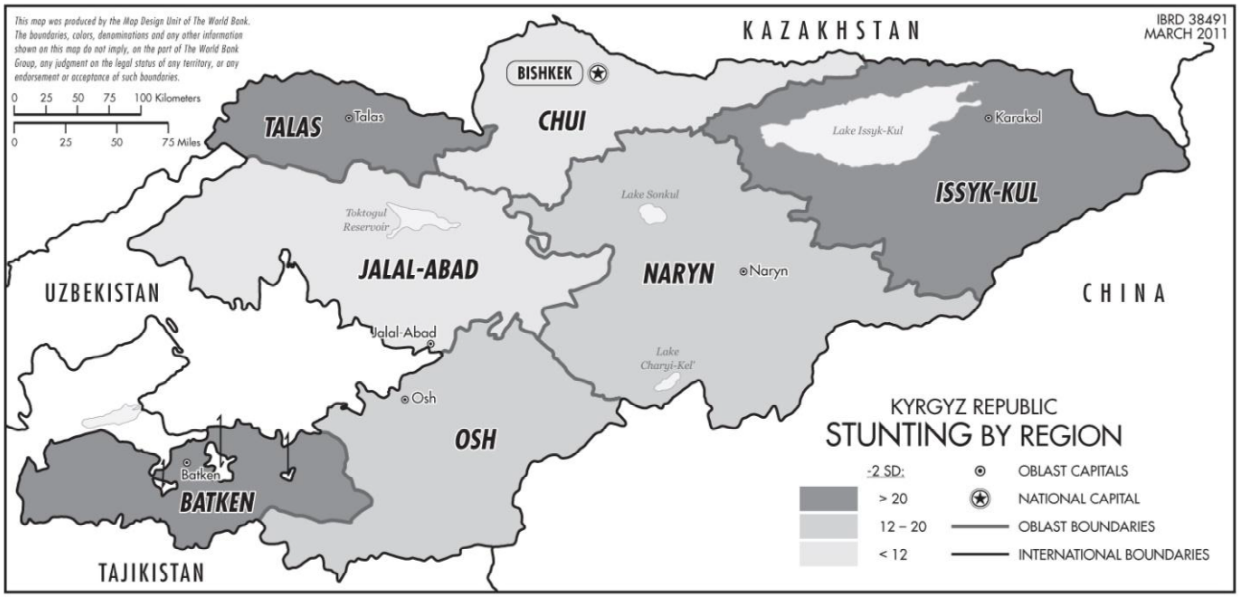
Globally, more than one-third of all child deaths are related to maternal or child undernutrition (UNICEF, 2009a). Stunting (being too short for one's age), severe wasting (being dangerously thin) and restricted fetal growth (intrauterine growth restriction) combined were responsible for 2.2 million deaths and 21% of disability-adjusted life years (DALYs) in children under 5 years in 2005 (Black et al., 2008). Additionally, vitamin A and zinc deficiencies were responsible for 0.6 million and 0.4 million deaths in the same age group, and vitamin A and zinc combined and iron and iodine combined were responsible for 9% and 0.2% of DALYs, respectively (Black et al., 2008). Beyond its physical health impacts, undernutrition diminishes cognitive development in children and directly prevents enrollment and attendance into primary schools in developing countries (Jukes, 2006). Alderman and colleagues compared stunted and normal children in Zimbabwe, reporting that stunted children were 3.4 centimeters shorter than the median child in developed countries, had completed 0.85 fewer grades of schooling and started school six months later (Alderman, Hoddinott & Kinsey, 2006).

One solution to address the dual impact of undernutrition on health and education has been school feeding, which is ubiquitous in both developing and developed countries (Gelli, 2010). School feeding may occur in primary schools or in preschools (Gelli, 2010; McKay, Sinisterra, McKay, Gomez & Lloreda, 1978). The term has also applied to meals prepared and served onsite at schools, such as breakfast, lunch and/or snacks, and to rations of commodities, such as flour or oil, which children take home to their families (Gelli, 2010). Most evaluations of primary school feeding in low and middle income countries have found that these programs increased enrollment, attendance and, variably, achievement on standardized tests (Gelli, 2010). However, the ability of school feeding programs to truly impact the nutrition of children, especially in developing countries, is still debated (Tomlinson, 2007). Some studies of school feeding programs have found positive associations with growth and micronutrient status, while others have found no growth effect and no impacts on certain micronutrient deficiencies (Kristjansson et al., 2007). In 2006, the World Bank released a report stating that there is little evidence that school feeding impacts nutrition, and because of cost-effectiveness issues, it may be displacing better programs such as deworming and iron supplementation, which have known impacts on growth and education (Tomlinson, 2007).

An underlying reason why some evaluations find minimal impact of primary school feeding programs on height may be the seeming irreversibility of stunting after three years of age (Tomlinson, 2007). There is a dearth in the literature with regards to evaluation of impact of pre-school based nutrition programs on the growth of children to test this hypothesis. However, studies of programs that provide take home rations to primary school students have found significant growth in the younger siblings of these students compared to the siblings of the control groups (Gelli, 2010). Such findings suggest that implementing school feeding during preschool years could positively impact nutrition. It could also increase enrollment and attendance in preschools, as it does for primary school, which, in turn, could improve school preparedness and later achievement in primary schools.

With current calls for scaling up effective interventions against malnutrition, evaluation of existing preschool based nutrition programs to isolate which variables are most effective in improving nutrition may provide needed evidence for governments and non-governmental agencies to continue to implement these interventions in institutional (school and preschool) settings. This study describes the impact of one particular school feeding program in one developing country. The Food for Education Program (FFE) is one of Mercy Corps's (MC) responses to poverty and malnutrition in Kyrgyzstan, where MC has been present since the fall of the Soviet Union.

The Situation in Kyrgyzstan



Map 1. Prevalence of stunting in Kyrgyzstan in 2006. The darker the shading of the Oblast or province in this map of Kyrgyzstan, the higher the prevalence of stunting in the area. Prevalence of stunting ranged from below 12% to above 20%. Taken from *Situational Analysis: Improving economic outcomes by expanding nutrition programming in the Kyrgyz Republic* by World Bank & UNICEF, 2011. p 30.

Nutrition. In Kyrgyzstan, Central Asia, malnutrition is a significant problem, costing the national government $32 million USD a year in lost productivity due to increased mortality and decreased physical and cognitive development (UNICEF, 2011). United Nation's Children Fund (UNICEF) estimates the rates of stunting in Kyrgyzstan for children under than 5 years to be 13.7% in 2006 (UNICEF, 2011). In 2006, undernutrition was an underlying cause for 22% of deaths (about 1547 deaths) and accounted for approximately 17% of DALYs in this age group (World Bank & UNICEF, 2011). Of the deaths due to undernutrition, severe and moderate stunting accounted for 50% and low birth weight accounted for 25% (World Bank & UNICEF 2011). Vitamin A deficiency accounted for 251 deaths and wasting accounted for 149 total deaths that year (World Bank & UNICEF, 2011).

No comprehensive micronutrient report has been published at the national level recently (UNICEF, 2011). Based on available data in 2007, there were 3238.6 new incidents of goiter per 100, 000 people (the lowest incidence since 2004), an outward symptom of iodine deficiency. The new incidences in goiter in 2004 for children younger than14 years ranged from less than 2000 in Naryn province to greater than 4000 in Jalal-Abad (UNICEF, 2009b). In 2003, 32.9% of all children 6 months to 5 years had low vitamin A levels, but the government has since been providing supplements to all children in that age range and their mothers in the first eight weeks following childbirth at coverage of 97% (UNICEF, 2009b). However, according to UNICEF, as of 2011, the Vitamin A supplement coverage for mothers was particularly low in Naryn, reaching only 9.6%. In 2008, 50.6% of children under five years and 25% of mothers in Talas had anemia due to iron deficiency (UNICEF, 2011).

Factors that contribute to malnutrition in Kyrgyzstan include high levels of food insecurity due to geography, inflation, high rates of poverty and political crises from 2008 to 2010. Prior to the energy crisis in 2008 and political upheaval in 2010, the child poverty rate in the country was very high and widely varied between the major cities and the rural areas (UNICEF, 2009b). According to UNICEF (2009b), in 2007, 49.7% of rural children in Kyrgyzstan were below the total poverty line; 9.2% were below the food poverty line (enough money to purchase food); and 9.6% were classified as severely poor based on the overall poverty line. Comparatively, only, 29.9%, 4.4% and 5.1% of children in urban settlements suffered from overall poverty, food poverty, or severe poverty, respectively. For example, while Bishkek city and the surrounding Province of Chui only had 6.8% and 22.5% overall poverty rates, respectively, the rural province of Jalal Abad had a rate of 57.1% and that of Osh had a rate of 56.0%. In 2007 through 2008, a harsh winter followed by low precipitation in the spring and summer of 2008 led to depletion of energy reserves (UNICEF, 2011). As a result, one in five households ate fewer meals of poor nutritional quality (World Bank & UNICEF, 2011). A drop in remittances due to the international economic crisis and soaring food and fuel prices greatly limited the purchasing power of vulnerable populations in the time leading to 2010 (UNICEF, 2011). In April of 2010, protests led to the overthrowing of the existing government and resulted in deaths and ethnic clashes in the southern region of the country, affecting the retail, manufacturing and even banking industry and further exacerbating the economic crisis (UNICEF, 2011).

Exacerbating the impact of poverty and political unrest on nutrition is the fact that the country has a predominantly mountainous terrain, which contributes to the food security issues in the country. Less than 8% of the land is suitable for cultivation (World Bank & UNICEF, 2011). Although 40% of the population is employed in agriculture, the main agricultural occupation is raising livestock (World Bank & UNICEF, 2011). Food security is, therefore, largely impacted by the harvest season. For example, in August 2010, during harvest season, severe food insecurity affected 4% of the population, but by March of 2011, this rate had increased to 14%, a level reflecting the depletion of harvested food as well as the lingering impact of the violence in 2010 (UNICEF, 2011). The level of severe food insecurity decreased to 2% during harvest season in 2012, but unhealthy coping habits persisted. In 2012, 20% of all food insecure households continued to cope with their food situation by reducing meal sizes and decreasing healthcare spending (WFP, 2012). Also, 26% and 12% of households in March of 2011 and 2012, respectively, continued to consume foods that were relatively non-diverse and unlikely to meet their nutrient needs (WFP, 2012). Because food insecure households were more likely to include children younger than five years, these negative practices in dealing with food insecurity could perpetuate the cycle of malnutrition in children.

Education. In 2007, the percentage of eighth graders in Kyrgyzstan passing literacy tests was problematic: only 11.8% passed in reading, 10.1% in mathematics, and 13.6% science (UNICEF, 2009a). According to a report by UNICEF (2009a), these low pass rates are in part due to poor preparation for school at the pre-school level. As of 2009, about 11% of all pre-school aged children in Kyrgyzstan have access to preschool, compared to about 15% in 2006 and 35% in 1990, the report stated. Those overall percentages hide the wide disparity between rural and urban areas. At 24% coverage, major cities had six times the coverage as some rural areas. As of 2009, more than 50% of rural districts in Batken and Issyk Kul had less than 5% pre-school enrollment (UNICEF, 2011). Those children who attended preschool were accommodated in only 567 state kindergartens, 351 community based kindergartens, and 27 private kindergartens (UNICEF, 2011).

A decline in the enrollment into preschool is exacerbated by parents failing to prepare their own children at home. When asked, only 30% of parents of children younger than five years old reported participating in the preschool preparation of their children (UNICEF, 2009b). In 2006, only 50.8% and 51.9% of children younger than five years old in Jalalabad and Naryn, respectively, were enrolled into four or more activities to promote learning and school readiness (UNICEF, 2011). This is due, in part, to the fact that parents often cannot find the information and support needed to participate in their child's development (UNICEF, 2009b).

The Mercy Corps Food for Education Program in Kyrgyzstan

An international crisis response and development agency, Mercy Corps (MC) first began Food for Education (FFE) in Kyrgyzstan to respond to the deterioration of many social services funded by the government, including education, after the fall of the Soviet Union in 1991. Since then, the programs, recruitment strategy, and delivery channels used by MC have remained largely unchanged. FFE 2010 was funded by the United States Department of Agriculture (USDA) and was a one year extension of an existing MC FFE program in response to increased food insecurity in the region stemming from droughts, economic crisis, inflation and revolutions. The program's goal was to empower communities and the government to achieve sustained, improved educational achievement in kindergartens in the most underserved educational institutions in 40 regions of the country, through the provision of commodities for warm, nutritious, in-school meals for 40,000 students (MC, 2009).

There were four components to the MC FFE program: 1) commodity distribution and monitoring; 2) capacity building through nutrition training for participants and stakeholders; 3) provision of infrastructure repair grants and expertise as needed; 4) development of vocational training programs for older students. Following is a brief description of the two components the author believes are most directly related to the goal of assessing impact on nutrition, namely, the commodities distribution and nutrition training.

MC distributed rice, vitamin A fortified, vegetable oil and flour to 500 institutions in March of 2011, benefiting 41,000 children in kindergartens, orphanages and boarding schools. Each participating institution received commodities in amounts to equal 50 grams of rice, 20 grams of oil and 50 grams of flour per child per day for nine months based on the total number of children that MC knew to be enrolled in the school (determined by head count during initial visit to the school). In addition, from January to November of 2011, MC nutrition specialists in partnership with the Ministry of Health and director of Maternal and Child Health Protection of Kyrgyzstan provided more than 601 training sessions to institutions. The classes provided very specific nutrition education to school nurses, cooks, directors (presidents), school board members and parent committee members about appropriate, balanced diets for children, food safety and mobilizing and managing resources for school nutrition programs. In coupling commodity provision with nutrition education, MC aimed to enable institutions to use resources not spent on staples (which were provided by MC) on diversifying the school menus.

All school feeding programs, including MC FFE, are based on a research supported theory which connects provision of meals with the ultimate outcome of improved education. The MC FFE program is based on a detailed impact theory developed by the USDA McGovern-Dole program, which consists of an intricate matrix of input, output and impact objectives ultimately leading to improved literacy for children with intermediate outcomes of improved enrollment and attendance. The full matrix can be found on the agency website at http://www.fas.usda.gov/excredits/FoodAid/Eval/MGDRFs.pdf and http://www.fas.usda.gov/excredits/FoodAid/Eval/MGDIndicators.pdf. For the purpose of this study, a modified impact theory was created to emphasize the focus on improved nutrition, see figure A1. The logic relies on research suggesting that school nutrition provides incentive for enrollment and attendance. Regular attendance by children increases the amount of days where children will be provided sufficient, nutritious meals, as a result of commodities and nutrition training for food preparers by MC FFE. Consumption of safe (assured through infrastructure repairs, when necessary), adequate foods regularly will lead to gains in height and weight and decreased risk of micronutrient deficiency, which in time, should lead to improved nutritional status in participating children.

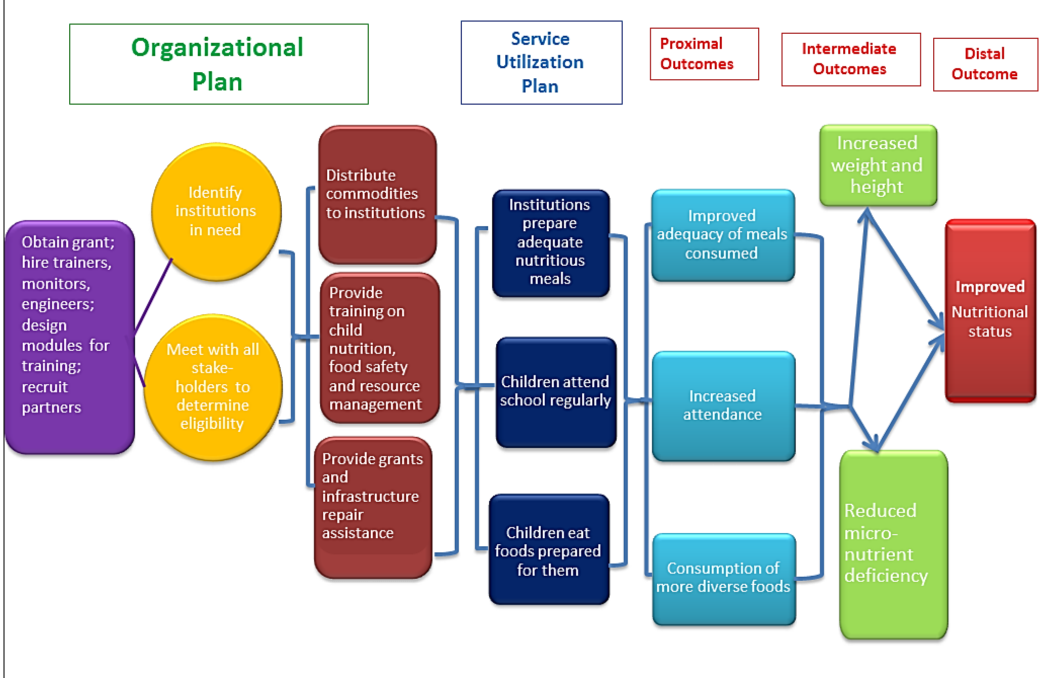


Figure A1. Logic model: how program leads to improved nutritional outcome. The diagram illustrates some of the necessary conditions for the MC FFE program to impact nutritional status. Adapted from MC FFE's 2011 grant proposal for renewal of the FFE program.

Purpose and Rationale

The purpose of this study was to describe the impact of a school based nutrition program on nutritional outcome, as indicated by anthropometry in Kyrgyzstani children. Mercy Corps Kyrgyzstan implemented a yearlong program that provided commodities, nutritional education, and infrastructure grants to public kindergartens in rural regions of Kyrgyzstan in hopes of improving literacy and nutrition. Now that the program has concluded, a main component of its impact evaluation was determining if there had been an improvement in nutritional outcome compared to baseline as indicated by changes in height and weight and the nutritional status indicators of stunting, underweight, wasting and obesity. The purpose of this thesis is to determine if the MC school feeding program led to improvements in growth. A secondary goal of this study was to assess which institutional characteristics were associated with differences in the nutritional outcome of children who participate in the feeding program.

This was primarily a descriptive study that utilizes monitoring data collected as part of the MC program and aimed to contribute to the literature on the impact of such programs on nutrition and nutritional outcome of children. The hypothesis of this study was that school feeding programs improve nutritional outcome amongst children who participate in them. The null hypothesis was that school feeding programs do not influence the nutritional outcome of children who participate in them. If the MC program improved child nutritional outcome, then similar school based feeding programs should be able to improve child nutritional outcome as well.

CHAPTER II

LITERATURE REVIEW

Prevalence and Impact of Undernutrition in Young Children

Anthropometry, the collective measurements of the physical dimensions of a human, is the method used by nutritional researchers to measure child growth. The simple measurements of height and weight are combined to obtain indicators of *faltered growth* in children, such as being underweight for one's age (*underweight*), being too short for one's age (*stunted*) and being dangerously thin (*wasted*) (WHO, 1995). Stunting, wasting and underweight are partially due to *undernutrition* or insufficient consumption or use of food energy and nutrients and are the predominant forms of abnormal anthropometry in the developing world (UNICEF, 2009a). In addition to having abnormal anthropometry, undernourished children may be deficient in several vitamins and minerals, collectively called micronutrients. These deficiencies have been statistically associated with poor anthropometry, even after controlling for environmental factors and social-economic factors which impact both conditions (Rivera et al., 2001). Following is a description of the prevalence and health and educational impact of childhood undernutrition.

Global prevalence of childhood undernutrition. Worldwide, 195 million children are stunted and 129 million are underweight (UNICEF, 2009a). Research shows that, in addition to its high prevalence, undernutrition also contributes greatly to morbidity and mortality from other illnesses. Stunting, wasting and underweight are associated with increased odds of mortality from diarrhea, pneumonia, malaria and measles (Black et al., 2008). According to the United Nations Children's Fund (UNICEF) (2009a), 90% of the 195 million stunted children reside in Africa or Asia. In examining the two continents, 40% of all African children in this age group compared to 36% of all Asian children are stunted. In some countries on both continents, however, there are more stunted children than there are normal ones. Nearly as prevalent as stunting, underweight malnutrition affects 129 million children under five years of age (constituting almost 25% of children in that age group), and 10% of this age group are severely underweight (UNICEF, 2009a). A slightly lower rate, 13% of children younger than 5 years in developing countries, are wasted and 5% (26 million of children) are severely wasted. In at least 17 developing countries, including many with stunting rates higher than 20%, the overweight rates range from 10% to 21%.

Unlike growth faltering, micronutrient deficiencies are prevalent in both developed and developing countries. Worldwide, about two billion people are micronutrient deficient (United Call to Action, 2009). According to UNICEF (2009a), an estimated 190 million (33%) of all preschool-age children are deficient in vitamin A (UNICEF, 2009a). In Africa and Asia, an estimated 40% of pre-school children suffer from this deficiency. Also, the report states, about 245 million children 0 to 59 months suffer from anemia, which is associated with iron deficiency. Most pre-school children in Africa (68%) suffer from iron deficiency. Iodine deficiency is prevalent in developed and developing countries, according to UNICEF. Fifty-two percent of European children and 42% of African children suffer from iodine deficiency.

Health impacts of childhood undernutrition. Using 388 national demographic health surveys of 139 countries with the highest burden of undernutrition, Black and colleagues (2008) estimated mortality and morbidity from poor nutritional status (faltered growth) and micronutrient deficiencies in young children and mothers. They determined that globally, the combination of stunting, severe wasting and restricted fetal growth (intrauterine growth restriction) were responsible for 2.2 million deaths and 21% of DALYs in children younger than 5 years of age. Combined, maternal and child undernutrition is related to 35% of disease burden in under five year olds and 11% of total global DALYS (Black et al. 2008).

Researchers believe that micronutrient deficiencies perpetuate the condition of abnormal anthropometry by increasing susceptibility to childhood illnesses, which in turn deters physical growth in children (Onyango, 2003). For example, zinc deficiency increases the risk of diarrhea, pneumonia and malaria, while vitamin A deficiency increases children's susceptibility to measles and respiratory infections (Black et al., 2008; Jukes, 2006). Research suggests that these gastrointestinal and febrile infections deplete nutrient stores and simultaneously lower food intake (Onyango, 2003). In a study conducted in Dhaka City, the authors found a significant difference in mean height-for-age z-scores between children who had up to three episodes of fever in the previous six months and their counterparts with no fever (Jesmin, Yamanmoto, Malik & Haque, 2011). In the study, those who had more than six episodes of fever in that time frame were more likely to be severely stunted. Diarrheal illness also has a strong, direct relationship with undernutrition, which is well documented in the literature. A meta-analysis by Checkley et al. (2008), which included over 1300 children in nine studies, found that every 5% increase in the number of days a child suffered from diarrhea before 24 months multiplicatively increased the odds of that child being stunted at 24 months by a factor of 1.16.

The health impacts of faltered growth continue into adulthood. Iodine deficiency is a leading cause of mental retardation, and about 70% of all new cases of complete and partial blindness each year are attributed to vitamin A deficiency (Black et al., 2008; Jukes, 2006). Children who experience faltered growth in childhood become at increased risk for diabetes, high blood pressure and heart disease (UNICEF, 2009a; Victora et al., 2008). A study in Finnish men born in the early 1900s found that boys born with low birth weights, especially in relationship to their length, had higher body mass index (BMI) in later childhood and adolescence, perhaps contributing to the increased prevalence of heart disease in the cohort (Eriksson et al., 1999). In that particular cohort, the average age of death due to heart disease for stunted men was 58 years old. In addition to the above health issues, females who experienced undernutrition before or during early childhood, if they remain stunted or thin in adulthood, have low birth weight babies later in life, thus continuing the cycle (Victora et al., 2008).

Impact on education. Abnormal anthropometry and micronutrient deficiency have been linked with diminished academic achievement. Children who were stunted by 2 years had lowered IQ and performed more poorly on 8 of 9 cognitive tests at 11 and 12 years old (Jukes, 2006). A study in Jamaica found that children at ages 7, 8, 9 and 14 who were hospitalized for severe malnutrition between 6 and 24 months lagged behind in reading and overall IQ tests by 1.50 and 1.33 standard deviations, respectively (Jukes, 2006). In children older than 27 months, a pooled analysis of five trials showed that for every decrease of 10 g/L of hemoglobin, indicating anemia due to iron deficiency and malaria, children's IQs dropped by 1.73 points (Black et al., 2008). Iodine deficiency reduces the likelihood of school enrollment as well as the academic performance of those who enroll by causing mental retardation in children (Black et al., 2008; Jukes, 2006; United Call to Action, 2009).

Some studies suggest that early faltered growth in childhood may impact education by delaying or preventing enrollment. A longitudinal study of the effect of a price shock in Pakistan on nutrition and health of children during preschool years found that being undernourished, as indicated by height-for-age, had a causal relationship with delayed enrollment into school (Alderman, Behrman, Lavy & Menon, 2001). Jukes (2006) suggested that delayed enrollment of children with abnormal anthropometry may be explained by parents in some countries only enrolling children after they have reached a certain height (due to long distances of walking to schools) and being unwilling to invest in the education of children considered to be sickly for whom education is considered to be a poor investment of limited resources.

Similar to its health impact, the educational impact of malnutrition continues into adulthood. Lower educational achievement may translate to lower economic status, and additionally, adults who were chronically undernourished children may be less productive at work and earn less than adults who were not undernourished as children (UNICEF, 2009a). Alderman, Hoddinott and Kinsey (2006) calculated lost earnings in their Zimbabwean cohort based on returns on education and age or job experience in the manufacturing sector in Zimbabwe. They determined that the later age of enrollment and lower number of accomplished grades meant a reduction in lifetime income of 14%.

Association of growth and nutrition

Evidence from global growth patterns. Using the World Health Organization (WHO) growth standards developed in 2006, Victora, Onis, de, Hallal, Blossner and Shrimpton (2010) conducted a reassessment of the timing of the incidence of growth faltering in children from 54 countries. They found that, globally, the length-for-age (stunting) curve began well below the reference curve, just above -0.5 z-score, and fell dramatically to a z-score of -1.75 below the reference at about 24 months. After this point, there was generally an increasing trend, though slight and never reaching above the -1.25 z-score line. Contrarily, the weight for length curve, which indicates wasting, began above the reference curve from 1 to 2 months, faltered slightly from 2 to 9 months, increased to the standard mean of the reference population at 24 months, and surpassed and remained above the standard beyond this point. This decrease of the global average length/height-for-age z-score (HAZ) to just above the -2 z-score mark is indicative of the fact that the highest prevalence of stunting, which is defined as a z-score lower than -2 on this indicator, is usually observed at 24 months (Onyango 2003). These findings have been interpreted as suggesting separate physiological pathways for stunting and wasting; for example, that stunting is the effect of the cumulative impact of suboptimum nutrition both pre and post natal, while wasting is only a reflection of more immediate deprivation(Bose et al., 2007; Victora et al., 2010). Being underweight is a composite of these two indices, which cannot specify which biological and physiological processes are in effect, but is helpful in indicating the presence of a problem in countries with no height data (Bose et al., 2007). In addition, this persistently low z-score in height-for-age after 24 months have been interpreted to mean that stunting is irreversible beyond the age of two years.

A second interpretation of the trends in height-for-age and weight-for-height z-scores is that poor feeding practices in early childhood is responsible, in part, for the development of poor nutritional status (stunting and wasting). Many children in developing countries are weaned of breast milk or introduced to complementary foods beginning at 3 months (Onyango, 2003). This early weaning, Onyango (2003) suggests, explains the incidence of wasting around three months. For those who continue breast feeding, breast milk can provide all required nutrients for children up to the age of six months, at which point it is internationally recommended that children be introduced to adequate and safe complementary foods in addition to breast feeding (Onyango, 2003). An assessment of 11 Demographic Health Surveys (DHS) of developing countries showed that, in six African, two Asian and three Latin American/Caribbean countries, only 28-47%, 36-44% and 16-22%, respectively, of infants between 6 months and 23 months received complementary foods the number of recommended times in the previous seven days (Arimond & Ruel, 2004a). Simultaneously, 5-59%, 22-35% and 21% of African, Asian and Latin American children, respectively, in the above age group received no solid foods in the previous seven days. In this sample, however, a high percentage of the children in each country were still breast fed, with the lowest rate being 47% and the highest being 96% (Arimond & Ruel 2004a). The high levels of inappropriate infant feeding practices found in the latter study would seem to support the assertion by the Onyango (2003) that such practices partially explains the incidence of growth faltering during infancy.

Evidence from supplementation studies. Additional information on the association of nutrition and growth is found in the literature on micronutrient interventions. The foods fed to young children in developing countries are frequently monotonous and bulky, lacking in both sufficient energy and micronutrients (vitamins and minerals) (Onyango, 2003), perhaps explaining why interventions that provide individual or multiple micronutrient supplementation generally impact growth positively in the literature. Zinc alone has been shown to have an effect on linear growth, especially in stunted children with low zinc serum levels (Bhutta et al., 2008). A pooled analysis of zinc-supplementation studies showed an impact on both weight and height gains, with average effect sizes of 0.31 and 0.35, respectively (Bhutta et al., 2008). In instances of severe vitamin A deficiency, vitamin A only supplementation has some impact on growth, (Bhutta et al. 2008; Rivera et. al. 2001). Similar to Vitamin A, Iron only supplementation has an impact on growth only in anemic children, but unlike Vitamin A, increases the incidence of diarrhea in malaria endemic areas (Bhutta et al., 2008; Rivera et al., 2001).

It has been suggested that the limited impact of single micronutrient supplementation interventions could be due to the fact that children often suffer deficiencies from multiple micronutrients (Alderman, Hoddinott & Kinsey, 2006; Rivera et. al., 2001). Rivera et al. (2001) provided children aged 8 to 14 months from a semirural setting in Mexico with one or 1.5 recommended dietary allowance of vitamins A through E and vitamin K, iron, zinc, iodine, and other micronutrients for 12 months. The authors reported a difference of 0.7 cm in height, corresponding to 0.33 units of HAZ for children who received micronutrient supplement compared to those in the placebo group. However, the difference in height between groups was only statistically significant for infants that were younger than 12 months at intervention initiation, which the authors concluded was due to the fact that infants grow at a faster rate than older children. Similarly, A meta-analysis of randomized controlled trials on 40 vitamin A, iron and multimicronutrient supplementation studies found no significant changes in height or weight of children under 18 years for vitamin A or iron alone (effect sizes were lower than 0.2 for both interventions on both types of growth) (Ramakrishnan et al., 2004). However, five studies which reported multiple micronutrients interventions had a pooled effect size of 0. 28 for height and weight each (Ramakrishnan et al. 2004). Additionally, both iron-only and multi-micronutrient supplementation during pregnancy reduced the risk of low birth weight in infants in other studies (Bhutta et al. 2008).

The small effects of multiple micronutrient interventions in children observed by Ramakrishnan and colleagues (2004; 2009) may indicate that much more than micronutrient supplements are required to prevent growth faltering after birth. For example, adequate healthcare may be lacking, or children could be unable to receive the amount of energy required or be deficient in other micronutrients than those reviewed in the literature thus far. Evidence from the dietary diversity literature shed additional light on this postulation.

Evidence from the dietary diversity literature. The same basic food groups are recommended by multiple nutrition regulating agencies in various countries: grains (daily), fruits and vegetables (daily), milk and dairy (daily), meat (2-3 times/week), fish (3 or more times/week), cheese (2 times/week), eggs (1-2 times/week) and legumes (2 or more times/week) (Horta, Pascoal & Santos, 2011). However, in many developing countries with the largest prevalence of poor nutritional status and micronutrient deficiencies, young children's diets often consist of one or two main carbohydrates, limited vegetables and, in some places, no animal source foods (Onyango, 2003). Staples supplemented only by seasonal vegetables and fruits often lead to a deficiency in vitamins, such as vitamin-A, and minerals, such as zinc, which have known functions in growth of preventing infection and increasing growth factor receptor and aiding tissue growth, bone formation and skin integrity, respectively (Onyango, 2003). Research has illustrated that having a more diverse diet (dietary diversity) is linked with consuming more food energy and obtaining the required amounts of various micronutrients.

A multitude of studies have correlated *dietary diversity scores* (DDS) with *nutritional adequacy* (meeting nutrients requirements) in children. One study found a significant correlation between consuming six out of eight possible food groups and meeting 75% of the recommended dietary allowance for fat and vitamins C and A in Malian children younger than 60 months (Ruel, 2003). Other studies conducted with infants and young children ranging from 9 to48 months in Guatemala, Kenya and Niger have also found an association between consumption of greater than five food groups

(Kenya) or six food groups (Niger) or membership in households with higher dietary diversity score based on individual foods consumed (Guatemala) and greater intakes of total energy, protein, fat, vitamins A and C, zinc, iron, riboflavin, niacin and calcium (Ruel, 2003). Presumably, improving the intake of these needed micronutrients through improving the diversity of nutrition would lead to improved physical growth, which would be reflected in stunting and wasting status.

Arimond and Ruel (2004a) tested the above hypothesis through an assessment of demographic health surveys from 11 countries. In their analysis of 11 African, Latin American and Asian countries, height-for-age was positively associated with DDS terciles either as a main effect or in interactions with covariates such as social-economic status (SES), breastfeeding, age or gender in 10 out of 11 countries. The relationship was modified by age group, so that in different countries, the difference in height-for-age scores between the lowest and highest dietary diversity terciles was more pronounced in 6-12 month-olds, 12-17 month-olds or 18-23 month olds. One benefit of this study was that it controlled for more demographic variables than most previous articles, allowing the interpretation that the correlations observed between DDS and stunting may be mostly independent of SES and other environmental factors.

Several other studies have reported positive associations between anthropometry and DDS. In Kenya, the number of individual foods consumed in 24 hours was associated with height-for-age (HAZ), weight-for-height (WHZ) and weight-for-age (WAZ) in 12-36 month olds after adjustment for age, household income, mother's education and breast feeding status (Onyango, Koski & Tucker, 1998). Findings in urban Mali, where lower food diversity scores were associated with twice the risk of being stunted or underweight, confirm these findings (Ruel, 2003). A study in Peru found that animal source foods interacted with overall dietary diversity and was strongly associated with length at 15 months in those children with low overall DDS (Ruel, 2003).

A weakness of many of these studies is the limited number of variables used in controlling for social economic status (SES) (Ruel 2003; Arimond & Ruel, 2004a). Thus, relationships reported between DDS and anthropometry may not be independent of the impact of SES (i.e. better access to healthcare and sanitation) on nutritional status. Furthermore, some studies have also found no association between DDS and anthropometry. In the Mali study, the association between the two factors was not observed in rural settings, only in urban ones (Ruel, 2003). Another study in Guatemalan 9-11 month-olds found no association between DDS and height-for-age or weight-for-height (Ruel, 2003). However, the relationship between anthropometry and DDS is likely robust due to the consistency with which it is documented in most studies across varying cultural settings and countries (Ruel, 2003; Arimond & Ruel, 2004a).

Issues in the measurement of dietary diversity. Dietary diversity scores (DDS) is a device used to quantify the number of food groups an individual consumes over a reference period. At its simplest, it is calculated by adding the number of different food groups a person reports that he or she has eaten in a given time frame (Ruel, 2003). Depending on the aim of the questionnaire, the basic required food groups, described above, can be broken down or combined to create categories ranging from 4 to15 or more (Ruel, 2003; Swindale & Billinsky, 2006). When assessing access to food in households is the goal, the United States Agency for International Development Food and Nutrition Technical Assistance II group (USAID-FANTA II, henceforth referred to as FANTA2) recommends that 12 food groups be assessed (Swindale & Billinsky, 2006). These include: cereals; fish and seafood; root and tubers; pulses/legumes/nuts; vegetables; milk and milk products; fruits; oil/fats; meat /poultry/offal; sugar/honey; eggs; and miscellaneous. However if the goal is to assess an individual child's dietary diversity, FANTA2 recommends eight food groups including: grains/roots/tubers; vitamin A-rich plant foods; other fruits or vegetables; meat/poultry/fish/seafood; eggs; pulses/legumes/nuts; milk/milk products; and foods cooked in oil/fat. Although the food groups included in the final DDS scores are fewer, obtaining individual dietary diversity for children requires expanding the fruit and vegetable categories in the DDS 12 questionnaire to distinguish between vitamin A rich and non-vitamin A rich foods. In some instances, individual foods eaten, rather than the group of foods eaten has been used, but a study has shown that, in developing countries, food groups are more predictive of nutrient adequacy than number of individual foods eaten, which may all be within the same food group (Daniels, Adair, Popkin & Truong, 2009; Ruel, 2003).

One important variable in obtaining dietary diversity scores is the reference frame used. As with all other aspects of DDS, reference frames can vary depending on the aim of the questionnaire. FANTA2 recommends that 24 hours be used to avoid recall bias when assessing household food access (Swindale & Billinsky, 2006). Multiple studies have found an association between DDS measured using this time frame and both nutrient adequacy and anthropometry, suggesting that it is in fact an accurate estimation of regular eating habits (Ruel, 2003; Arimond et al., 2010). However, programs have used various recall periods ranging from 24 hours to 15 days, a practice which has made comparing scores across programs difficult (Ruel, 2003; Swindale & Billinsky, 2006). A study that explored increases in individual food variety consumed over a 15 day reference period found that the most rapid increase in food variety for individuals happened over 3 days, slowing until 10 days and ceasing to change between 10 and 15 days (Ruel, 2003). This finding illustrates that the longer the reference period, the higher the DDS is likely to be. However, most foods needed by children need to be consumed with some regularity, certainly more than once in a week (Arimond & Ruel, 2004b). Arimond and Ruel (2004b) compared the agreement between dietary diversity measured over 24 hours and over seven days, where only foods eaten three days out of the seven were counted. They found that Nepal, the percent of people who have had the same number of food groups in the last 24 hours, for three days out of the last seven, or at least one day out of the last seven were 16%, 9% and 38%, respectively. In most countries, such extreme differences were not observed, however. In Malawi, Benin, and Cambodia differences in agreement between the 24 hour recall and 7-day recall where only foods eaten for at least three days were counted were less than 10%, and in Zimbabwe, Ethiopia, Rwanda and Peru, they were 5% or less (Arimond & Ruel 2004b). The authors suggest that, where the goal is to assess general food patterns for an individual, these two measures may be equally useful.

A second complicating variable in interpreting and comparing DDS is that of scoring. Food group scoring methods have ranged from simply tallying the number of food groups consumed (most frequently used) to assigning scores based on the frequency of consumption or portion size (Ruel, 2003). In general high DDS scores often correlates with both intake and adequacy, regardless of the method used in tallying the score (Ruel, 2003). However, a simple list based DD questionnaire does not actually provide any information on dietary adequacy. In Ethiopia, a wide range of foods were consumed in quantities insufficient for biological use (Daniels, Adair, Popkin & Truong, 2009). Daniels, Adair, Popkin and Truong (2009) explored the relationship between portion size and the ability of DDS to predict nutrient adequacy by assigning both a simple diversity (food group eaten or not) and a minimal portion size (10 g) score for nine food groups eaten by 24-month old Filipino children. Both types of diversity scores were significantly correlated with meeting 75% of the recommended daily allowance for various nutrients, but the 10g portion requirement had a stronger correlation. Similarly, a study in women of child bearing age in resource-poor setting, compared food consumed at a minimum of 1g and only those consumed at 15 g or more, and discovered that instituting a higher portion size requirement on DDS score led to a stronger correlation with nutrient adequacy (Arimond et al., 2010). When the goal is assessing the adequacy of a diet, excluding foods eaten in extremely small quantities may improve the DDS obtained.

The discrepancies in measurements of dietary diversity poses a problem not only in interpreting past studies, such as those described in the previous section, in light of each other, but they also make designing new studies somewhat difficult. Since there are no actual globally accepted standards for measuring and assessing DDS, the choice of which method to use is quite arbitrary, though usually based on the author's logic.

Despite this limitation, the literature consistently supports DDS as a good measure of dietary quality (healthy diet) and adequacy (foods meet nutrient requirements) and suggests that DDS can explain some of the relationship between anthropometry and nutrition.

Nutritional Impact of School Feeding Programs

Traditionally, school feeding has meant on-site meals or snacks provision to children in order to enhance learning and increase access to education through the reduction of short term hunger (Gelli, 2010). In developing countries, school feeding can take many forms, including take-home rations given to children who meet attendance cut-offs, usually of 80%; in school meal provision and take home rations; provision of micronutrient fortified foods or snacks; and additional healthcare intervention along with meal provision (Gelli, 2010; Tomlinson, 2007). In general, school feeding programs have been shown to have a robust and generally positive impact on enrollment, attendance and achievement in schools both in developed and developing countries (Brown, Beardsley & Prothrow-Stith, 2008; Gelli, 2010). The evidence of its impact on micronutrient status and growth, however, continues to be disputed. Reports by both the World Bank (Tomlinson, 2007) and by Bhutta and colleagues (2008) state that there is little evidence that school and preschool feeding programs have nutritional impacts. However, the only meta-analysis to date, a review of school feeding in the developing and developed countries and several studies published post the afore mentioned reports have described school feeding programs as having generally positive impact on growth and micronutrient status, especially in younger populations.

One assessment of school meal programs in the developed country setting was commissioned by Sodexo Foundation and explored the impact of the US School Breakfast Program on nutrition amongst other outcomes (Brown et al., 2008). The ensuing review of 100 peer reviewed articles found that US school breakfast programs increased blood glucose, increased consumption of quality foods (increasing milk and fruit intake and decreasing fat intake) and established better eating habits in children. Additionally, the review found that levels of micronutrient deficiencies in vitamin C, E and folate were reduced amongst those who consumed school breakfasts in some schools. Similarly, a meta-analysis of school feeding programs based in developed countries found significantly higher weight and height gain in treatment groups compared to control in four studies (Kristjansson et al. 2007).

The study mentioned above is the only meta-analysis to date to assess the impact of onsite school feeding on various outcomes in children ages 5 to 19 from all countries. The study by Kristjansson and colleagues (2007) reported that children gained 0.39 kg over 19 months and 0.71 kg over 11.3 months compared to control in randomized controlled trials (RCTs) and controlled pre-post trials (CBA), respectively, in developing country settings. The gain in CBA studies represents a 3.9% difference relative to baseline and 44% greater gain than control. The only RCT to assess it found a significantly higher gain in weight-for-age z-score in the experimental group than the control, but the sole CBA study found no significant difference between control and experimental groups. Only one RTC in a developing country setting reported on height, and that study observed 0.2% change in height from baseline to follow-up in the experimental group. In the RTC, the difference in height gains between experimental and control groups were statistically insignificant. However, there was a significant gain in height of 1.43 cm in CBA studies. This change in height resembled a 1.2% increase in height compared to baseline and 33% greater gain than control. There was also a small but significant difference in the change in height-for-age z-scores in experimental and control groups which favored experimental groups in both RCTs and CBAs.

Only one RCT in Kenya reported data on biochemical assessments of micronutrient levels in students in the Kristjansson study. The study evaluated several indicators of micronutrient status, including hemoglobin, plasma ferritin and vitamin B-12, serum iron, zinc and copper, folate, retinol and erythrocyte riboflavin. Increase in vitamin B-12 levels alone was significantly different compared to control after a year of intervention.

The Kristjansson (2007) study is significant in being the first meta-analysis of school based feeding programs. However, despite a total of 18 studies, many of the outcome specific meta-analysis in this review included only one or two studies. Therefore, it would be risky to draw conclusions on the potential of such programs to impact growth and micronutrient status in some instances. Additionally, the interventions included only provided 195-730 Kcal and 3-27 grams of protein per child per day, with three of the nine studies in developing countries providing less than 15% of daily energy requirement for children in primary schools (Kristjansson et al. 2007). The authors suggest the modest impact detected in some programs could be due to the amount of energy and nutrient provided as part of these meal programs. Furthermore, the study does not report on the impact of interventions on nutritional status (stunting or wasting) prevalence, which would be more indicative of whether or not the program improved outcome. However, while some individual studies showed no significant impact of the school based feeding program on nutritional outcomes, the majority of studies included and the overall meta-analysis seemed to show modest but positive impact, especially on weight and height.

More recent studies have reported positive impact of school meal programs on growth and micronutrients as well. A study of 469 primary school children in Tehran, Iran provided 250 milliliters of milk per day for three months to children in four schools in medium socio-economic status regions (Rahmani et al. 2011). Children were weighed on a digital scale and their heights measured using a basic tape measure both before and following the intervention. Nutrition education in homes and amongst students on the benefit of drinking milk assured compliance by the second week of the intervention. At follow-up, only girls showed significant difference in weight and mid-arm circumference compared to control. No significant association was found for boys or girls with height.

This study had several short comings, including limited control for environmental factors and short duration.

Another study, a longitudinal assessment of a national school snack program in Bogota Columbia, showed similar impact potential given longer duration. The program described by Arsenault and colleagues (2009) provided 30% of energy and 50% of iron daily requirements to primary school children aged 5-12 years, an approximate 1600 kcal of energy and 9 mg of iron, respectively, to children younger than eight years and 1800 kcal and 13 mg of energy and iron, respectively, to children eight years or older. Additionally, the program provided supplements of 40% of daily requirements for calcium. Snacks were in the form of a beverage, cereal or protein snack, peanuts or cheese and fruit, arranged in 9-days menu rotation, where fruits were in five of the nine menu options. Compliance was ascertained through direct teacher observation of snack eating. Baseline and follow-up anthropometry, biochemistry, morbidity as well as SES and demographic data were obtained. After adjustment for SES and other school interventions, children receiving school snack had higher increases in plasma B-12 and lower decreases in HAZ compared to control at three month follow-up. In addition to growth and nutritional impact, the study reportedly reduced morbidity from fever, cough with fever, diarrhea and diarrhea with vomiting by 40%, 57%, 30% and 55%, respectively. Although BMI was assessed, there were no significant differences observed, which could be due to the short duration of the study. However, no significant differences were observed in hemoglobin, ferritin (iron indicator) or folate compared to control. The authors speculate that inability to detect differences in ferritin or hemoglobin could be due to a simultaneous independent iron supplementation intervention that was also taking place in the communities.

Several issues with the described studies illustrate criticisms that opponents of school feeding programs have pointed out. One is the methodological issues with study designs, such as lack of a control group in some instances, which make it difficult to attribute results to program impact. An assessment of the quality of research studies in school feeding was an additional benefit of the Kristjansson (2007) study. Many studies, per these authors, were mere descriptions of nutritional quality of school meals or of program and management, or else were longitudinal or cross sectional studies with no controls. The authors claim to have found only 12 additional studies (excluded) to the 18 included in the meta-analyses which had reasonable rigor, and these spanned eight decades. Another issue, observed in the milk supplementation study in Iran, is that of limited control for social economic and demographic factors that could influence results observed. A third issue illustrated by the Colombia study is that the growth is sometimes assessed after only a short period of time, due to external constraints, making it difficult to capture any real change in growth which the program may have influenced. These issues may explain the small effects or else lack of effect observed in many studies.

Another key criticism of school feeding is that of timing, or their implementation in primary school settings. As mentioned earlier, research has shown recovery from poor nutritional status, specifically stunting, to be unlikely after two years of age (Victora, Onis, de, Hallal, Blossner & Shrimpton, 2010). Opponents have argued that finite food resources should be given to infants and young children, in whom they are more likely to influence growth and outcome (Tomlinson, 2007). Though this seems a logical suggestion, especially given some of the beneficial impact on growth in younger siblings of primary school students provided with take home rations at school (Gelli, 2010), very few studies have assessed the impact of pre-school feeding on growth in developing countries. Despite the general dearth of research on the topic, the few studies published indicate that such programs positively influence nutrition and growth at the preschool age.

Two studies evaluated either growth or micronutrient status in children six years or younger, or the traditional pre-school age, and one assessed growth and micronutrient status in 6-8 year olds. One study assessed the impact of participation in communal day care center feeding programs on nutrient intake and nutritional adequacy (Harding et al., 2012). Children in day care centers with communal feeding programs brought either food or money for resources to their schools, where meals were prepared and served to all children in attendance during lunch. 24-hour recalls were used in home interviews of parents to obtain a record of all foods consumed the previous day for every weekday. Additionally, quantity of meals consumed at daycare as well as the ingredients was used to calculate the total energy consumed. It was discovered that children participating in the daycare centers consumed more meals (four compared to three), thus had high total energy intakes, about 20% more energy. These children exceeded the recommended daily intake of energy protein, vitamin A, thiamine, niacin, vitamin C and iron, while those attending daycares without feeding programs only exceeded the requirement for protein, vitamin A and vitamin C. In model controlling for energy intake, it was determined that participation in the daycare feeding program was a negative determinant of meeting zinc and iron intake. The authors concluded that the feeding program increased quantity but not necessarily quality of foods consumed by children. However, as interventions can increase the quality of food served (i.e. fortification), the feeding program showed potential to have a positive impact on the nutrition of children.

The second study in pre-school aged children was by Zavoshy and colleagues (2012) and provided 320 kcal energy, 17% protein, 53% carbohydrate and 30% fat requirements daily to 2385 children mostly five (range 3-6) year olds in nurseries in rural Iran. Children were provided cooked lunch meals of lentils, rice, spaghetti, potato, tomato paste, onion and bones for 175 days, and weight and height were recorded before and after the program. Average weight increased from 14.67 kg to 15.84 kg and height from 94.69 to 97.76 cm. The prevalence of wasting in boys and girls combined was significantly reduced from 15.2% at baseline to 13.1%. The study did not report on stunting.

An additional study in Cape Town, South Africa and Kenya assessed growth and nutrition of 6-8 year olds. The study by Kruger and colleagues (1996) provided unfortified and iron-fortified soup with and without deworming treatment to school children, and assessed weight, height, weight-for-age (WAZ), height-for-age (HAZ) and weight-for-height(WHZ) before and after treatment. In addition to one cup of soup, children were given up to two slices of bread and 10ml of peanut butter for 6 months. In children who had low iron stores at baseline, weight gain ranged from 2.2 kg in unfortified soup group to 2.8 kg in the iron and deworming treatment group, and height gain ranged from 5.1 cm to 6.1 m, respectively. WAZ gain was second highest in the unfortified soup group with 0.12 points and highest in the iron fortified soup with deworming treatment at 0.22 points. HAZ decreased in the unfortified soup only group, the only indicator to do so. Iron fortified soup with and without deworming and unfortified soup with deworming treatment all led to gains in HAZ ranging from 0.06 to 0.13 points after five months. WHZ also increased for all groups, ranging in points from 0.10 with unfortified soup with deworming treatment group to 0.25 points in the fortified soup and deworming treatment group. Those children who had normal iron stores at baseline gained slightly higher weight and 5.8 cm, regardless of group at 5 months follow-up. The intervention also led, as would be expected, to improvements in iron, anemia and infection (by worms). There were no control groups that did not receive soup, making it difficult to assess the direct impact of simply providing food without fortification or additional treatments. However, gains in the unfortified soup only group suggest that the meal alone improved WAZ and WHZ scores.

Implication of literature review

In conclusion, the global prevalence and impact of undernutrition suggest that the issue of undernutrition is a major one with highly detrimental health, educational and financial repercussions for individuals and society. Understanding the relationship between food and nutritional status or faltered growth clarifies where and when interventions are needed to prevent this condition. Although a host of interventions at the community level exist and have been recommended for improving nutritional outcome, the paucity of well-designed research on school, especially pre-school, feeding programs have led experts to recommend against it in resource poor settings, when the dual impact of malnutrition on education and health seem to make such programs intuitive. The few studies found in this review suggest that preschool feeding programs positively impact nutritional outcome, and that it is poor research rather than a lack of impact that is the issue. Unfortunately, only one such study reported on nutritional status indicators, which are better indication of nutritional outcome rather than height and weight gain or z-scores. One way to determine whether or not in school feeding in developing countries has an impact on nutritional outcome is to continue to evaluate new and existing pre-school feeding programs, like the Mercy Corps Food for Education program, for their impact on nutritional status.

CHAPTER 3: METHODOLOGY

This investigation was designed to assess the impact of a school feeding program, the Mercy Corps Food for Education Program (MC FFE), on nutritional outcomes of children between two and eight years based on selected indicators (stunting, wasting, underweight, obesity). This analysis is designed as a quantitative program evaluation of the MC FFE focused on nutritional outcome.

Study Objectives

The goals of this study were two-fold: 1) to evaluate the impact of the MC FFE on the nutritional outcomes of children in the participating institutions, and 2) to determine which factors are correlated with growth in these children. The specific objectives were to:

1) Assess changes in anthropometric (height, weight, HAZ, WAZ and BAZ) measurements of children before and after the MC FFE program implementation

2) Assess changes in the nutritional status indicators of stunting, wasting, being obese and being underweight in children from pre to post program implementation.

3) Assess institutional characteristics and program components that explain variation in changes in nutritional status.

The main hypothesis addressed in this investigation is that there will be improved nutritional status in children participating in the MC FFE program institutions, and that differences in degrees of improvement will be, at least partially, explained by the institutional and child characteristics

Variables

In this study, nutritional status, an indicator of nutritional outcome, were assessed. For the purposes of this study, the main indicators of nutritional outcome are stunting, wasting, being underweight and being obese. Dietary diversity is used as a proxy of nutritional quality. Multiple studies have correlated dietary diversity scores (DDS) with both nutritional quality and nutrient adequacy (Ruel, 2003). Due to the fact that this program was not designed as a research study, few demographic data were collected on children. The only demographic variables readily available were those required for anthropometric calculations, including age and sex. All other variables were institutional level variables and were directly related to the program outcome assessment. For example, data was collected on the state of kindergarten infrastructure, on grams of food served to each child each day and number of food groups consumed in a week (dietary diversity). The region which an institution is located in is considered a variable as well, due to major variations in levels of malnutrition between states in Kyrgyzstan described in the background section of this paper.

Independent variables. The independent variables for this study are provided in table S3.1which shows how variables were measured. Dietary diversity is a covariate rather than a true independent variable, while stunting (at baseline) is an independent variable, because it is not impacted by any program activities and has been shown to be linked with the degree of change in nutritional status (Gelli, 2010). Furthermore, stunting is a proxy measure of historical child health and nutrition, as it is a result of chronic hunger and repeated illness caused by broad demographic and social factors experienced at home and society at large (Gorstein et al., 1994). Therefore, by taking into account baseline stunting, it may be possible to control for the issue of external and home factors which influence the child’s growth beyond the institution to a small degree.

Table S3.1: List of independent variables

Variable	Definition	Unit	Rate of measurement	Source of data
Age	Age from birth to day of baseline or post measurement	Months		MC FFE collected at time of anthropometric measurement
Sex/Gender	Biological sex of child participant			MC FFE collected at time of anthropometric measurement
Infrastructure repair	Rated kitchen, latrine, heating, ceilings, windows and/or doors as being in need of partial and or total repair	A rating of greater than 4 on a 5-point scale	Measured once	MC FFE baseline questionnaire
Total funding	Total funding from all sources for nutrition program in KGS (USD/45)	KGS/child/day	Measured once	MC FFE baseline questionnaire
Region	Location of the kindergarten in the north or south of the country			Baseline questionnaire

Number of meals served	Number of meals, including breakfast, lunch, snacks and dinner served	number of meals	Measured once	MC FFE obtained in baseline questionnaire
Amount of foods served	The total grams of all ingredients prepared for all the meals in one day divided by the number of children in attendance that day to obtain the total grams/child /day totaled over all the work days the institution had throughout program life	Total grams/child	Daily	MC FFE monitoring data obtained during monthly visits to the institution
Dietary Diversity	Number of food groups served to children in preceding 7 days or 7 working days averaged over the total number of months the institution was opened	Average dietary diversity score	Monthly	MC FFE monitoring data Obtained during monthly visits to the institution

Number of work days	The total number of days the institution was open throughout program life	Number of days	Monthly	MC FFE monitoring data Obtained during monthly visits to the institution

Dependent variables. The dependent variables are the nutritional status indicators stunting, wasting, underweight and obesity. They were measured based on the World Health Organization (WHO) standard (in children younger than 61 months) and reference (in children older than 61 months) (WHO, 2008, 2009) as follows:

1) Stunting is having a standard deviation score from the reference population means (z-score) less than -2.00 for height-for-age (HAZ)
2) Underweight is a z-score less than -2 on the weight-for-age indicator (WAZ)
3) Wasting is a z-score less than -2 on the BMI for age indicator (BAZ)
4) Obese is a BAZ greater than +3 in children under 61 months and greater than +2 in children above 61 months.

WHO AnthroPlus for PCs

The WHO AnthroPlus for Personal Computers (AnthroPlus) was used to calculate weight-for-age, height-for-age and BMI-for-age z-scores of children, HAZ, WAZ and BAZ, respectively. The AnthroPlus is software designed specifically for assessing child growth using the WHO growth standards and references released in 2006 and 2007, respectively. The Nutritional Survey module of the software as used in this study requires the researcher to produce the height in cm, weight in kilograms, date of birth, date of measurements, sex of the child and whether or not the child has Oedema or was measured recumbently. With this information, the software calculates the exact age in days (if child is under 61 months) or months (if child is 61 months or older) to use with the WHO growth standard or references, respectively. The software compares the measured height for each child to the WHO growth standard (0-5 years) or WHO reference (5 to 19 years) population medians for the relevant ages and genders. Z-scores are generated by subtracting the median value of the reference population from the height or weight of each child in the sample and dividing the difference by the standard deviation of the reference group (WHO 1995). The AnthroPlus automatically determines which reference population to use based on the child's age.

Source of Data

All data used in this study were collected by MC staff as part of the FFE 2010 program which was implemented from October of 2010 to April of 2012. Consent to gather this information was obtained by MC staff from all stakeholders of each institution before the institution could become a part of the program. Monitors visited each participating kindergarten once a month to collect data. All data collected were coded by MC staff, and this study is a secondary assessment of this de-identified data provided by MC. Following is a brief description of the data collection process.

Recruitment.MC recruited institutions from its existing list of all schools in the country and also from a list obtained from the minister of education of all government funded schools. The eligibility criteria included having both a storage room for commodities and a kitchen, receiving financing from the government, the ability to transport produce from MC warehouses to the schools and willingness to follow all program protocols including measurements and monitoring visits. Institutions were excluded if any of the following were true:

-received funding from the state greater than or equal to 65 soms (KGS)/ child / day (US $1.00 = 44 KGS)

-only children older than 5 years live in or attend the institution

-received humanitarian assistance in the form of products, in particular from the World
Food Program

-had a sufficient number of products in stock with a stock agency for several months

-departmental or private kindergartens

-located in a regional center or in major cities, such as Osh, Bishkek, and Kara Kol

-served only one meal/day

- building was in disrepair

-had no power supply system

-parental contribution was greater than or equal to 800 KGS / month/child

-received assistance from other donors.

For interested institutions, all stakeholders, including representatives of parent teacher associations, parents, school governing board and the president of each kindergarten were required to meet with MC staff, so that the program could be explained and approved by them. A total of 500 institutions, including kindergartens, orphanages and boarding schools were chosen to be part of the program, with preference given to institutions with the least resources.

Collection of Monitoring Data

Baseline questionnaire.MC administered a baseline questionnaire to all interested institutions during the months of November and December of 2010 in order to determine which institutions were eligible for the program. This questionnaire had 11 items with many questions having multiple other sub questions. Key information obtained in this questionnaire included baseline dietary diversity (described in detail below), number of days in the week that the institutions worked, types and amount of funding for feeding programs, numbers of students registered and self-reports about the state of the heating system, water system, toilets, kitchen facility, doors, windows, and floors and ceilings.

Anthropometry. Baseline anthropometric measurements were collected in May of 2011, with a few institutions not completing measurements till early June of 2011. Post measurements were completed in March of 2012. At baseline, 60 institutions were randomly selected from a list of 470 kindergartens and orphanages that MC had worked with previously. RASOFT software was used to conduct the simple random sampling of institutions. Measurements were taken for every child present on the day of measurement in each institution that was selected. For the post measurements, all the children present in the same institutions used in baseline measurements were measured. However, the only children whose data are included in this study are those who were also present at baseline. The same commodity monitor assigned to each particular institution completed both baseline and post measurements. The heights of children were measured with a simple tape measure brought by the commodity monitor. In instances when children had on bulky shoes or high pony tails, they were instructed to remove them. The weights were obtained using a simple, digital weighing scale, which was brought by the MC monitor. Here children were asked to dispose of heavy jackets and sometimes shoes. Each child's name, age and gender were obtained from school records at the time of measurement. All information was entered into an excel sheet on a small laptop computer in the field.

Dietary diversity. A simple list questionnaire was administered at baseline (November through December 2010) and every month from May of 2011 until March of 2012. The questionnaire included 32 questions and inquired about 16 food groups and the source of each food group (i.e. was it borrowed, bought on credit, donated or bartered against other goods). The commodity monitors orally inquired of the school director or cook the same questions for each food group:

> "Did anyone at your institution consume the following products in the last 7 days? If yes, how many days?"

Due to a misunderstanding, the monitors in the north of the country all defined seven days as seven calendar days, while those in the south defined 7 days as seven working days. In the northern region of the country, DDS would reflect foods eaten in five working days for kindergartens in session five days out of the week or six working days if the institution was in session for six days and so forth. Contrarily, the DDS scores in the southern region of the country would always reflect foods eaten for seven business days. It was discovered that all the institutions selected for anthropometric assessments only worked five days during the week. Therefore, the DDS scores in the north reflect 5 days, while those in the south reflect 7 days. As a result, the scores in southern institutions could be relatively inflated.

The sixteen food groups inquired about are Flour/Grain, potatoes, Yellow/Orange vegetables, Dark green vegetables, Other vegetables, Yellow/orange fruits, Other fruits/Jams, Meat (beef, pork, liver etc.), Eggs/poultry (turkey, chicken, etc.), Fish, Legumes (peas, beans, nuts), Milk/dairy, Oils/fats, Sugar/honey, Other seasonings/condiments, Coffee/tea. Only foods served at a quantity of 5 ounces (5 grams) or greater could be listed. This amount was set intentionally low by the program director in an attempt to capture all foods being consumed at whatever quantity. Scoring is based on a binary system in which a score of 1point is ascribed for each food group that is served in the institution, and 0 represents its absence.

Meal size, attendance and enrollment. To determine the quantity of foods being consumed by each child, institutions were required to weigh each dish after its preparation. The total grams of foods prepared for each meal was divided by the total number of children in attendance that day, determining the grams per child per meal; the grams per child at each meal was then tallied for all meals served that day to obtain an estimate of each child's total gram consumption per child per day. This total also includes snacks served to the children each day. The data was recorded daily by the school chef and director and provided to the commodity monitors during the monthly visits.

Daily attendance was obtained by the institution. In addition to providing daily attendance records, the institution was asked to calculate the number of children who were absent for greater than 50% of the working days of the month. The institution also maintained records of new children enrolled every month and provided this to the monitors on a monthly basis. It was discovered towards the end of the program that institutions were counting as drop-outs children who transferred to different classrooms within the same school, thus causing these same children to be counted as new enrollees by the new teacher. Additionally, teachers reported children as absent in their reports to MC, even if the children were absent due to school closing for weather or infrastructure reasons. The enrollment and attendance data were determined to be difficult to interpret.

Statistical Analysis

All statistical analyses were conducted with SPSS 16.0. Tables and figures were recreated in Excel. A few variables were recoded in order to enter them into the statistical analysis. Firstly, the dietary diversity scores were averaged over the total number of months the scores were collected for each institution during the program life. The DDS score for each month was tabulated as follows:

> KDDS 8 (Kindergarten dietary diversity scores) = Grains/potatoes + vitamin A fruits/vegetables (Yellow/orange fruits and vegetables) + other fruits/vegetables (dark green vegetables/other fruits and vegetables) + meat /fish + legumes + poultry/eggs + milk/dairy + oils/fats.

The final dietary diversity for the month was determined by scoring the total number of these food groups served to children at an institution for three or more days of the preceding 7 days, as reported by the cook or school director.

Second, the total amount of funding per institution does not include humanitarian funds, which were only received by two institutions in the south and in relatively high amounts, greatly skewing this data. Once this particular source of funding was eliminated, those same institutions had very low values in total funding, which is more likely to reflect the reality of the relationship between those institutions and others in the program in terms of funding for their school feeding program. Third, new variable “in need of repair" was created based on a self-rating score of greater than 4 on anyone of the kitchen, latrine, heating, ceilings, windows or doors categories in response to the question "What best describes the condition of …?" Those institutions meeting this criterion received score of 1 and all others receive a 0 in the new variable.

All tests were assessed at 95% Confidence Interval and $p < 0.05$.

Pre and post assessment of anthropometry. A Frequency analysis and chi square test for significance and paired t-test in instances of continuous variables were used to assess for significant differences in these variables from baseline to post program implementation.

Assessment of factors associated with nutritional outcome in program participants. A chi square assessment was conducted to assess association between nutritional outcome variables and the institutional variables (table S3.1) of region, province, baseline dietary diversity score, need of repair and total non-humanitarian funding and demographic variables of age and sex (of child) at baseline. In instances of low expected values, Fisher's Exact p-values were used instead of Pearson Chi square p-values. The one way ANOVA and Tuckey post hoc assessments or independent sample T-test were used to assess the associations of these explanatory variables and height, weight, WAZ, HAZ and BAZ. Tables S3.2 and S3.3 show the results of these assessments for stunting, wasting, underweight and obesity. However, due to a low prevalence of all of the other conditions both at baseline and follow-up, only stunting was used in logistic regression models. Funding and dietary diversity, explanatory variables that were significant in this initial assessment, were used in the logistic models described below. Additionally, program components, including grams of food provided daily and total number of days of program were entered in the logistic models.

A separate analysis to assess for the potential confounding effect of region and province with the other explanatory variables was conducted. In the south only, child's gender became significantly associated with stunting at baseline ($p < 0.05$). No additional variables became significantly associated with stunting at baseline when each region was assessed separately. Furthermore, variables that were initially significantly associated with stunting at baseline remained significant at the same level when the two regions were assessed separately. Theoretically, province is a likely confounder and was associated with all other explanatory variables and covariates (Table S3.4). However, due to small number of cases and the relatively large number of categories within this variable (7 provinces), which there is no proven method of combining beyond grouping as belonging to the northern or southern region, it was not possible to use this variable in logistical models. Instead, region was used as a proxy for the potentially confounding impact of geography and associated implementation differences on nutritional outcome. This decision was also based on the fact that when both region and province were included in a logistic model, the variable of region was automatically eliminated from the model. This seemed to suggest a strong relationship between the two variables in their ability to predict stunting.

Two different set of logistic models were conducted. One set of models assessed the impact of institutional covariates and demographic variables with being stunted (yes = 1 or no = 0) at follow-up. A second set of models assessed the ability of institutional and demographic variables to predict improvement in stunting status from baseline to post. For this second model, N was the number of children who were stunted at baseline, while in the first model N was the total number of children with pre and post anthropometric measurements. In both model, crude and adjusted models for each institutional and demographic variable were first conducted, with the only adjustment variable being region based on the result of the initial assessments described above. Two types of multivariate logistic models were then constructed using each of the two types of outcomes already stated. With each type of outcome, one model was conducted that only included variables that were significantly associated with stunting at baseline or were specifically components of the program treatment (i.e. food served), while in a second model all potential explanatory variables and covariates, barring province were forced into the model.

CHAPTER IV: RESULTS

Baseline

The baseline anthropometry of children and institutions characteristics can be found in table 1 and 2. At baseline, 60 kindergartens were randomly selected from 470 kindergartens, boarding schools and orphanages (table 1). The averaged dietary diversity score was 5.83 ± 1.3 out of 8 possible points for foods eaten at least three days out of seven, and all institutions were open five days per week. There were 1280 children total, 642 of whom were male and 638 of whom were female. The mean age, weight and height were 57.21 months, 17.02 kilograms (kg) and 104.12 centimeters (cm), respectively. The youngest child was less than two years (22.5 mos.), and the oldest was 7 years (87.4 mos.). Height ranged from 78 cm to 132 cm, and weight ranged from 10.3 kg to 31.9 kg.

The mean height-for-age (HAZ), weight-for-age (WAZ) and body-mass-index (BMI)-for- age (BAZ) were -0.82, -0.36 and 0.23, respectively. The lowest and highest z-scores for HAZ were -5.21 and 4.06, respectively; for WAZ, -3.29 and 3.87, respectively; and for BAZ,-4.30 and 4.89, respectively. At baseline, 14.8%, 2.2%, 3.3% and 1.9% of all children measured were stunted, wasted, underweight and obese, respectively.

Table 1. Basic institutional characteristics at baseline

	N (Institutions)	Mean ± SD	95% C.I.
Student per Institution	60	30.9 ± 17.5	--
Days/week	60	5 ± 0	--
Hours/day	60	9.4 ± 1.4	9.3, 9.44
Funding (soms/child)	60	25.7 ± 9.0	25.24, 26.23
Dietary diversity	60	5.83 ± 1.3	5.75, 5.90

Table 2: Baseline anthropometry and nutritional status

Variable	Sample Size	Mean ± SD	95% C.I.

Age (mos)	1280	57.3 ± 10.3	56.7 - 57.8
Weight (kg)	1280	17.0 ± 2.3	16.9 - 17.2
Height (cm)	1280	104.1 ± 7.4	103.7 - 14.5
HAZ	1280	-0.82 ± 1.2	-0.89 - -0.76
WAZ	1280	-0.36 ± 0.93	-0.41 - -0.31
BAZ	1280	0.23 ± 1.1	0.17 - 0.29

Variable	Sample Size	Percentage (%)
Stunting	1280	14.5
Wasting	1280	3.1
Underweight	1280	3.6
Obesity	1280	1.6
Normal	1280	81.7

Impact of losing children to follow-up. There were a significant percentage of children lost to follow-up. A total of 526 (41%) of students were lost between the first and second anthropometric measurements and two institutions were eliminated altogether due to complete loss of all the students who were measured at baseline. A comparison of baseline descriptive statistics and nutritional status for children who were lost to follow-up and those retained are presented in table 3. On average, those lost to follow-up were 3 months older, 0.35 kg heavier and 1.26 cm taller at baseline than those retained till follow-up. The differences were statistically significant in all cases at $p < 0.01$. However, in assessing, HAZ, WAZ and BAZ between the two groups, there was no significant difference between them, with the exception of WAZ. Similarly, the frequency of stunting, obesity and underweight were slightly higher at baseline in the group lost to follow-up, while wasting was slightly lower, but these differences were also not statistically significant.

For the purpose of this study, only children with two measurements (N =754) (table 3) were considered in assessments of association. At baseline, these children were 55.99 ± 9.76 months, 16.88 ± 2.29 kg and 103.60 ± 7.25 cm. The average HAZ, WAZ and BAZ were -0.81 ± 1.20, -0.34 ± 0.92 and 0.25 ± 1.14, respectively. The prevalence of stunting, wasting, being underweight and obesity were 13.8%, 3.4%, 3.2% and 1.2%, respectively.

Table 3: Comparison of children with two measurements and with one measurement

A. Mean differences in select variables for those with two and one measurements

	Two measurements	One measurement		
Sample Size	754	526		
Variables	Mean ± SD	Mean ± SD	Mean difference	95% C.I.
Age (mos)	55.99 ± 9.76	59.1 ± 10.9	-3.11	-4.24,1.96
Weight (Kg)	16.88 ± 2.29	17.23 ± 2.43	-0.35	-0.61, 0.85
Height (cm)	103.60 ± 7.25	104.86 ± 7.50	-1.26	-2.09,0.44
HAZ	-0.81 ± 1.20	-0.85 ± 1.15	0.05	-0.08, 0.18
WAZ	-0.34 ± 0.92	-0.40 ± 0.93	0.06	0.05, 0.17
BAZ	0.25 ± 1.14	0.20 ± 1.09	0.05	-0.07, 0.18

B. Frequency of select conditions

Variable	Percent (%)	Percent (%)	P-value
Stunting	13.8	15.4	0.42
Wasting	3.4	2.7	0.43
Underweight	3.2	3.6	0.35
Obesity	1.2	1.9	0.42

Follow-up

Table 4 shows institutional characteristics at follow-up. The average time elapsed from baseline to post measurements (not shown in table) was 9.94 ± 0.52 months with a range from 8.97 to 21.95 mos. Two institutions in Osh included at baseline were eliminated at follow-up. Hence, the total number of institutions with two measurements of children for all anthropometric indicators was 58. On average institutions were open for 243.87 ± 23.05 days, served 595.82 ± 168.82 grams of food/person/day and scored 5.48 ± 0.59 out of 8 possible points on dietary diversity based on foods eaten for at least 3 days out of seven for all months that the institutions were open.

Table 4. Basic institutional characteristics at follow-up

Variable	N(Institutions)	Mean ± SD	95% CI
Duration (days)	58	243.87 ± 23.05	242.22, 245.52
Amount of food (g/person/day)	58	595.82 ± 168.82	583.75, 607.89
Dietary diversity	58	5.48 ± 0.59	5.44, 5.53

Table 5 describes participants' characteristics at follow-up and amount of change from baseline to follow-up. The average weight and height at follow-up were 19.06 ± 9.73 kg and 109.60 ± 6.5 cm, respectively. On average, each child had gained 6.0 ± 3.35 cm and 2.18 ±1.39 kg in height and weight, respectively. At follow-up, the average HAZ ± SD, WAZ ± SD and BAZ ± SD were -0.58 ± 1.06, -0.14 ±0.99 and 0.32 ±1.03, respectively. Z-scores increased by 0.22 ± 0.73, 0.19 ± 0.54 and 0.06 ± 0.91 for HAZ, WAZ and BMI, respectively. The prevalence of stunting, wasting, underweight and obesity at follow-up was 8.6%, 2.1%, 2.3% and 3.7%, respectively. There were percentage point decreases of 5.2, 1.0 and 1.3 in the prevalence of stunting, wasting and underweight, respectively. Obesity alone increased in prevalence by 2.4 percentage points. The decreases in the levels of stunting, wasting and underweight and the increase in the level of obesity from baseline to follow-up were significant ($p < 0.001$), after excluding the aforementioned students who were lost to follow-up). The percentage of normal children increased from 82.1% to 85.8%, an increase of 3.7 percentage points, from baseline to follow-up ($p < 0.01$).

Table 5. Follow-up anthropometry and nutritional status

		Follow-up		Change from baseline	p-value
Variable	Sample Size	Mean ± SD	95% CI	Mean ± SD	

Age (mos)	754	65.9 ± 9.7	65.2, 66.6	9.93 ± 0.52	<0.01
Weight (kg)	754	19.1 ± 2.6	18.9, 19.2	2.18 ± 1.39	<0.01
Height (cm)	754	109.6 ± 6.8	109.1, 11.1	6.0 ± 3.35	<0.01
HAZ	754	-0.58 ± 1.1	-0.66, -0.51	0.22 ± 0.73	<0.01
WAZ	754	-0.14 ± .90	-0.21, -0.08	0.19 ± 0.54	<0.01
BAZ	754	.31 ± 1.0	0.24, 0.39	0.06 ± 0.91	0.06
Variable	Sample Size	Follow-up (%)		Percentage point from baseline	p-value
Stunting	754	8.6		-5.2	<0.01
Wasting	754	2.1		-1.3	<0.01
Underweight	754	2.3		-0.9	<0.01
Obesity	754	3.7		2.4	<0.01
Normal	754	85.8		3.7	<0.01

The frequency analysis revealed interesting dynamics in the change in each nutritional outcome indicator from baseline to post (Figure 1-4). Of 104 children initially stunted 53(50%) improved and were no longer stunted at follow up. However, 14 children (2% of all children), who were normal at baseline, became stunted by follow-up. All but one of the new incidences of stunting was in children in the south, while the north and south had very similar numbers of improved children. As shown in figure 2, 13 or 50% of children who were underweight at baseline were no longer underweight at follow-up, but 6 (1%) children who were normal at baseline became underweight by follow-up. There were equal number of new incidences in underweight in the north and south, but a higher proportion (7 of 9) of northern children recovered from underweight than southern children (6 of 15). In figure 4, 17 of 26 or 65% of wasted children improved, while 7 (1%) of children who were normal at baseline became wasted by follow-up. By follow-up, 85% of children in the north and 57% of children in the south had recovered from wasting. Finally, figure 5 shows that 10 children (1.2%) were obese at baseline and 18 more (3%) became obese by follow-up. The initial number and new incidence of obesity were higher in the north. Unlike the other indicators, no child that was obese at baseline became normal by the end of the program. In all cases excepting obesity, the south had greater initial levels of the condition and greater or the same number of new incidences.

Figure 1. Distribution of changes in stunting

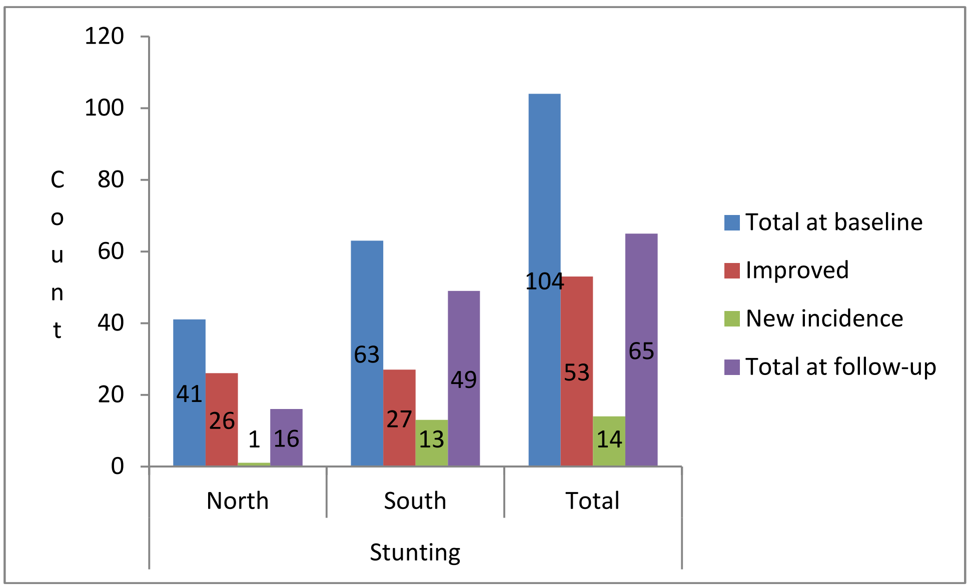


Figure 2. Distribution of changes in being underweight

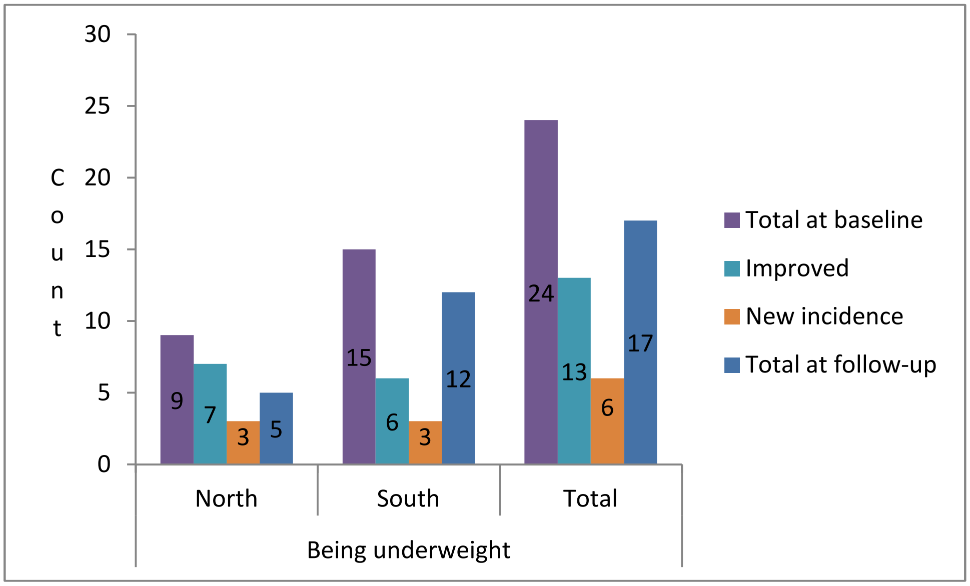


Figure 3. Distribution of changes in wasting

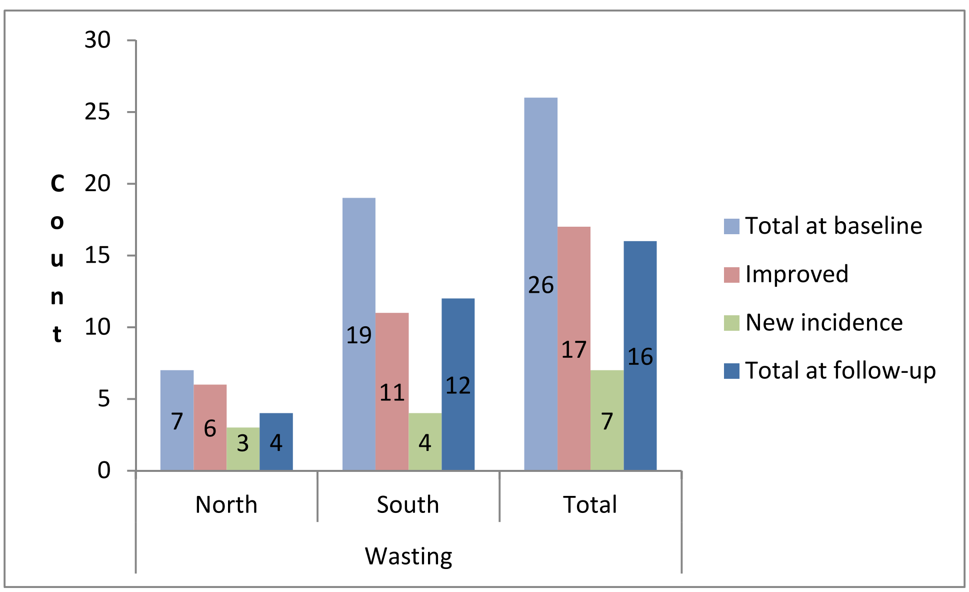
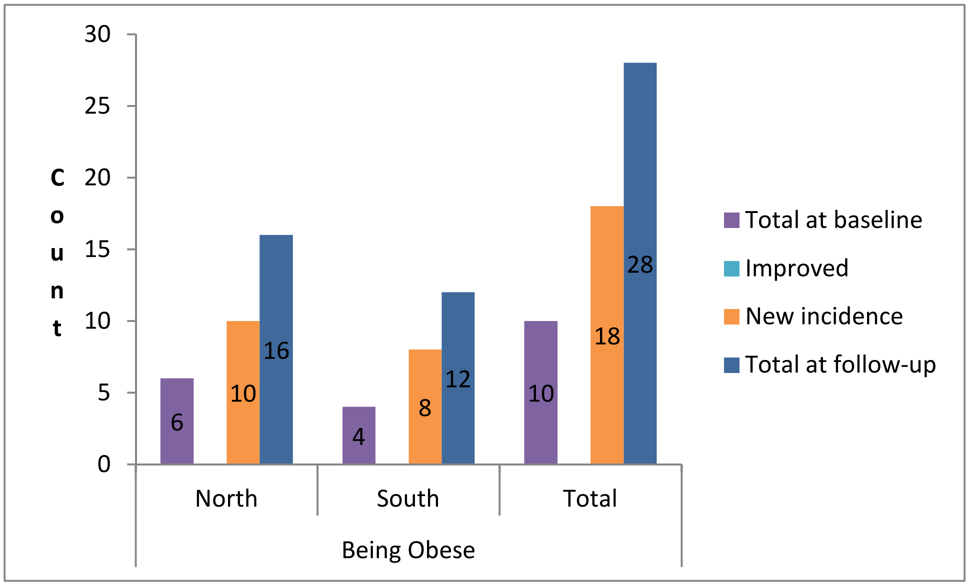


Figure 4. Distribution of changes in being obese



Factors Associated with Change in Nutritional Status and Anthropometry.

The institutional characteristics considered in this study were 1) Oblast (state),2) region (north or south), 3) funding for feeding program prior to MC intervention in 2010, 4)quantity of food consumed per child per day as part of MC program, 5) whether or not the institution was likely to receive repairs (self-rating of the state of school infrastructure), 6) kindergarten dietary diversity scores (KDDS), and 7) the total number of days the institution remained open during the intervention period. Age and sex of children were also considered. It was determined that all institutions were open the same number of days out of the week and also served three meals, and thus, these variables were eliminated from further analysis. Due to smaller rates of underweight, being wasted and obesity both at baseline and post, these indicators of nutritional outcome were not assessed statistically. Therefore, only stunting was compared across institutional variables to assess for any association and is reported below.

Distribution of improvement in stunting and stunting at follow-up across select variables. Table 6 and 7 are cross tabulations and comparisons of means of select institutional and child characteristics between those who improved and those who did not improve in stunting status from baseline to follow-up. Of those stunted at baseline, 26 in the north (63.4%) and 27 (42.9%) in the south were no longer stunted at follow-up. The north and the south were statistically different from each other on the rate of improvement (p = 0.04). Twenty-two (50%) of children that attended institutions that scored lower than 4 on infrastructure repair need in all areas and 31 (51.7%) in those that scored higher than 4 improved in their stunting status by follow-up. Twenty-seven females (57.4%) and 26 males (45.6%) improved in stunting status by follow-up. The mean ages at baseline of those with improvements in stunting and without were 56.19±10.09 and 58.0±9.32, respectively. Those with improvement and without were served 608.11±197.82 and 546.19±148.16 grams of food per day, respectively and attended institutions which were opened 240.13±19.20 and 243.61±21.88 days, respectively. The average dietary diversity for those with and without improvement in stunting was 5.55±0.64 and 5.44±0.58, respectively, out of eight possible points. Funding for school nutrition programs for those without and with improvements at follow-up was 23.04± 8.10 and 24.18 ± 7.66 soms (Kyrgyz currency), respectively.

Table 6. Comparison of improvement in stunting across select variables

Variables (unit)		Not improved	Improved	p-value
Region				0.04
North	%	36.6	63.4	
South	%	57.1	42.9	
Repair Score				0.87
Score <4	%	50	50	
Score >= 4	%	48.3	51.7	
Gender				0.23
Male	%	54.4	45.6	
Female	%	42.6	57.4	
Amount of food (g)	Mean ± SD	546.19 ± 148.16	608.11 ± 197.82	0.07

Duration (days)	Mean ± SD	243.61±21.88	240.13 ± 19.20	0.39
Dietary diversity	Mean ± SD	5.44±0.58	5.55 ± 0.64	0.36
Funding (soms)	Mean ± SD	23.04± 8.10	24.18 ± 7.66	0.46
Age (mos)	Mean ± SD	58.09±9.32	56.19 ± 10.09	0.32

Table 7 displays comparisons of those who were stunted at follow-up, irrespective of baseline stunting status, by select institution and child characteristics. Out 754 children, 65 were stunted at follow-up. The mean age at baseline of those stunted and normal at follow-up was statistically similar, 58.0 ±9.14 months and 55.80±9.80 months respectively. The total number of days kindergartens were open was 243.68±23.28 for normal children and 245.95±20.50 for stunted children. The difference between stunted and normal children was not significant for either of the preceding variables. The amount of funding the institutions received for nutrition and the grams of food served per day were significantly different between stunted and normal children at follow-up, 547.98±148.37grams and 600.34±170.03 grams, respectively, ($p = 0.02$) and 22.45±7.59 soms and 26.67±8.73 soms, respectively, ($p < 0.01$). Sixteen (4.8%) and 49 (11.7%) of children in the north and south, respectively were stunted at follow-up. The rate of stunting in the south was statistically higher than in the north ($p < 0.01$). Ten percent of males and 6.9% of females were stunted at follow-up. Eight percent of those who scored lower than 4 and 9.2% of those who scored higher than 4 on infrastructure repair need in all areas were stunted at follow-up. The rate of stunting between male and females and schools who scored higher or lower than 4 repair need were statistically similar.

Table 7. Comparison of stunting status at follow-up across select variables

Variables (unit)		Normal	Stunted	p-value
Region				<0.01
North	%	95.2	4.8	
South	%	88.3	11.7	

Repair score				0.56
Score <4	%	92	8	
Score >= 4	%	90.8	9.2	
Gender				0.11
Male	%	89.8	10.2	
Female	%	93.1	6.9	
Amount of food (g)	mean±SD	600.34±170.03	547.98±148.37	0.02
Duration (days)	mean±SD	243.68±23.28	245.95±20.50	0.45
Dietary diversity	mean±SD	5.48 ± 0.59	5.47±0.60	0.85
Funding (soms)	mean±SD	26.67±8.73	22.45±7.59	<0.01
Age (mos)	mean±SD	55.80±9.80	58.0±9.14	0.08

Crude and adjusted logistic models for improved stunting status. Table 8 displays the results of the univariate test of association for institutional and child variables and improvement in stunting status from baseline to post in crude form. As shown in this table, region alone was significantly associated with change in stunting status from baseline to post. Those in the south were less likely than those in the north (O.R. 0.43, $p < 0.05$) to have improved from being stunted at baseline to not being stunted at follow-up. Twenty-six or 63% of children in the north and 27 or 42.9% of children in the south who were stunted at baseline became normal at follow-up. Adjusting for region had no impact on the significance of the association between any variables and improved stunting but instead diminished the significance of region in all the models (tables not shown).

Table 8. Univariate analysis of association between select variables and improvement in stunting, crude model

Variables	O.R.	95% CI Lower	95% CI Upper	P-value
Gender				
Female (Ref)				
Male	0.62	0.28	1.35	0.23

Region				
North (Ref)				
South	0.43	0.19	0.97	0.04
Repair				
Score 4=< (Ref)				
Score <4	0.93	0.43	2.04	0.87
Amount of food	1	1	1	0.08
Duration	0.99	0.97	1.01	0.39
Dietary Diversity	1.36	0.71	2.59	0.36
Age	0.98	0.94	1.02	0.32
Funding	1.02	0.97	1.07	0.46

Tables 9 and 10 show the result of the multivariate assessment of association between institutional and child variables and improvement in stunting status. One multivariate model adjusted for region and amount of funding as institution characteristics and dietary diversity, grams of food per day and total days that the institution was opened were included as program specific institutional characteristics. In this model, grams per day, region and funding for school nutrition program were significant. Each unit increase in grams of food consumed per day increased the odds of improvement in stunting status from baseline (O.R. = 1.003, $p < 0.05$). Attending an institution in the south (O.R. = 0.17, $p < 0.05$) as well as unit increases in funding (O.R. 0.88, $p < 0.05$) for nutrition programming were both associated with reduced odds of improvement in stunting. In a model that included gender (table), only region and funding for school feeding were significant. Attending an institution in the south remained significantly associated with lower odds of improvement in stunting status (O.R. = 0.17, $p < 0.05$). Each unit increase in non-humanitarian funding for the school feeding program was significantly associated with decreased odds of improvement in stunting status from baseline to post (O.R. = 0.87, $p < 0.05$).

Table 9. Multivariate analysis of improvement in stunting and select variables, not including gender

Variables	O.R.	95% C.I.		P-value
		Lower	Higher	
Region				
North (Ref)				
South	0.17	0.04	0.82	0.03
Amount of food	1.003	1	1.006	0.049
Duration	0.98	0.96	1.01	0.21
Dietary diversity	1.63	0.74	3.59	0.23
Funding	0.88	0.79	0.98	0.02

Table 10. Multivariate analysis of improvement in stunting and select variables, including gender

Variables	O.R.	95% C.I.		P-value
		Lower	Upper	
Region				
North (Ref)				
South	0.17	0.04	0.8	0.02
Gender				
Female (Ref)				
Male	0.65	0.28	1.51	0.32
Amount of food	1.003	1	1.006	0.058
Duration	0.98	0.96	1.01	0.21
Dietary diversity	1.65	0.74	3.67	0.22
Funding	0.87	0.78	0.97	0.02

Crude and adjusted logistic models for stunting at follow-up. Table 11 displays the results of univariate tests of association between select institution and child characteristics and being stunted at follow-up. Attending an institution in the south was associated with increased odds of being stunted at follow-up (O.R. 1.48, $P < 0.01$). Funding for school nutrition program was significantly associated with lowered odds of being stunted at follow-up (O.R. = 0.94, $p < 0.05$). Grams per day was also significant, however the odds ratio was only slightly lower than 1 (O.R. = 0.99, $p<0.05$). After adjusting for region, none of the variables, funding included, were significantly associated with stunting at follow-up.

Table 11. Univariate analysis of association between select variables and being stunted at follow-up

Variables	O.R.	95% C.I. Lower	95% C.I. Upper	P-value
Gender				
Male (Ref)				
Female	0.66	0.39	1.11	0.11
Region				
North (Ref)				
South	2.66	1.48	4.76	<0.01
Repair				
Score <4 (ref)				
Score 4=<	1.16	0.7	1.94	0.56
Amount of food	0.99	0.99	1	0.02
Duration	1	0.99	1.02	0.45
Dietary diversity	0.96	0.62	1.48	0.85
Age	0.96	0.62	1.48	0.85
Funding	0.94	0.91	0.97	<0.01

Table 12 and 13 show the results of a multivariate test of association for institutional and child characteristics. As is shown in the tables 12, grams of food served per day and the total days the institution was open during the program period each had O.R. of 1.0. Funding had a slightly lower O.R. of 0.96. However, the p-values were not significant for any of the variables assessed. Including gender did not impact the odds ratios or the p-values for any of variables.

Table 12. Multivariate analysis of stunting at follow-up and select variables, not including gender

Variables	O.R.	95% C.I. Lower	95% C.I. Upper	P-value
Region				
North (Ref)				
South	1.64	0.68	3.95	0.27
Amount of food	1	0.998	1.002	0.79
Duration	1	0.98	1.01	0.65
Dietary diversity	1.08	0.7	1.65	0.74

Funding	0.96	0.91	1.01	0.57

Table 13. Multivariate analysis of stunting at follow-up and select variables, including gender

Variables	O.R.	95% C.I.		P-value
		Lower	Higher	
Region				
North (Ref)				
South	1.62	0.67	3.9	0.28
Gender				
Female (Ref)				
Male	1.5	0.88	2.54	0.13
Amount of food	1	0.998	1.002	0.81
Total days	1	0.98	1.01	0.62
Dietary diversity	1.08	0.7	1.66	0.72
Funding	0.96	0.91	1.01	0.12

CHAPTER V: DISCUSSION

The primary purpose of this study was to determine if there were improvements in the nutritional outcome of children as a result of the Mercy Corps Food for Education program (FFE) implemented from December of 2010 until April of 2012. The results of the MC FFE program show that there was a significant decrease in the level of stunting from 13.8% (N= 754) at baseline to 8.6% by follow-up, a decrease in prevalence by 5.2 percentage points. The reduction in the proportion of stunted children corresponds to the recovery of 50% of children who were stunted at the start of the program. This reduction in stunting is due to a great deal of catch-up growth in participants, who gained an average of 6 cm in 10 months, corresponding to an average increase in height-for-age z-scores (HAZ) by 0.22 points. The levels of wasting and underweight also decreased from baseline to follow-up assessment, while the level of obesity increased. There were percentage point decreases of 1.0 and 1.3 in the prevalence of wasting and underweight, respectively, and a 2.4 percentage point increase in prevalence of obesity due to participants gaining an average of 2.2 kg, corresponding to an increase of 0.19 points in weight-for-age z-scores (WAZ) and 0.06 points in BMI-for-age z-score (BAZ).

Similar magnitudes of gains in height and weight to those observed in the current assessment have been reported by another school meal program in Cape Town, South Africa, by Kruger and colleagues (1996). Increases in weight five months after provision of iron-fortified soup and deworming treatment ranged from 2.2 kg in fortified soup only to 2.8 kg in the group that received both fortified soup and deworming therapy, if the child suffered from low iron stores initially. Weight gains in children with adequate iron stores were only slightly higher. If they suffered from low iron stores, children in the unfortified soup only group gained 5.1 cm, while those in the fortified soup and deworming therapy group gained 6.1 cm, and the other two groups ranged between these. If they had adequate iron stores, children gained 5.8 cm, regardless of treatment group.

The Cape Town food for education program yielded similar or higher gains in WAZ or BAZ, but lower gains in HAZ than the MC FFE program. Children gained from 0.07 to 0.22 points in WAZ in the four treatments and control groups five months after the intervention if they suffered from low iron stores initially. Gains ranged from 0.02 to 0.19 points in WAZ for children with adequate iron stores. Gains in HAZ and weight-for-height z-scores (WHZ) ranged from 0.03 to 0.08 points and 0.08 to 0.25 points, respectively, for children with adequate iron stores and -0.03 to 0.13 points and 0.10 to 0.25, respectively, for children with low iron stores initially. Although there were two types of treatment and controls, all groups received soup for six months, whether fortified or not. Because follow-up was five months after intervention, the amount of time is roughly similar to the time span reflected in growth measurements for MCFFE as well. The higher end of the range in gains on both WAZ and WHZ, which is comparable to BAZ, are higher than the gains observed in MC FFE. However, MC FFE led to a higher gains in HAZ points, a fact that could be related to a higher proportion of the sample in the Cape Town being stunted initially (17.9% as supposed to MC FFE's 13.8%).

The magnitude of the gains observed in the current study may be due in part to the FFE providing a higher proportion of the daily energy requirement for children and also targeting younger children than some other programs reviewed. The review by Kruger and colleagues of the Cape Town food for education program did not report on the total energy per day provided to children, but only reported the provision of one cup of soup, two slices of bread and 10 ml of peanut butter daily. It is safe to assume that most of children's energy requirement came from other sources, and the high impact of the program may have been due to the fortification and deworming therapy, which were also the focus of the evaluation. The impact of fortification and deworming therapy may have been particularly pronounced in that sample, because a high proportion of the children were iron deficient and infected with worms. A study by Kristjansson et al. (2007), a meta-analysis of studies of school feeding programs for children ranging in age from five to 19 years, reported that many programs only provided a small portion of participants' energy requirement, about 195-730 Kcal, and protein requirements, 3-27 grams. The authors reported weight gain equal to 3.9% of baseline value in treatment groups for controlled pre-post trials only. While in the MC FFE program the weight gain is about 12.9% of baseline values. Height gain in the controlled pre-post studies was 1.2% compared to baseline in experimental groups, while in the MC FFE study, the height gain is about 5.8% of baseline values. Kristjansson and colleagues postulated that small proportion of energy and nutrient requirements provided may have been partially responsible for the minimal impact observed in the meta-analyses. The MC FFE provided the complete daily energy requirement, on average 595.82 grams of food/person/day, for nearly 10 months. Since MC provided rice and wheat flour, it could be postulated that all the food was composed of complex carbohydrate for the purpose of determining how much energy the child would have received. In reality, menus were more diverse, and this amount of food included protein and fat as well vitamin A from the fortified vegetable oil. In any case, if we assume that all the food were carbohydrates, then 595.82 grams of food would provide approximately 2383 kcal/person/day (124% and 122% of the WHO and US guidelines, respectively, for children under 10 years old). This amount is probably a low estimate of how much energy was provided, since fats are higher in energy content than carbohydrate and children's diets at these institutions would have included fat from the oil and other sources.

The only evaluation of a pre-school meal program reviewed that reported impact on nutritional status only reported on wasting status. Zavoshy and colleagues reported 2.1 percentage point decrease in wasting after providing 3 to 6 years old children with 320 kcal, 17% protein, 53% carbohydrates and 30% fat daily for 175 days. The larger reduction in prevalence of wasting in the Zavoshy study could be due to a much higher prevalence of wasting in the population included in that particular study, 15.2% wasted at baseline.

No school feeding program reviewed reported impact on stunting or underweight. However, some evaluations of community based food supplementation using fortified foods have reported positive impacts. An impact evaluation of 29 programs under the United States Agency for International Development (USAID) Title II Maternal and Child Health and Nutrition (MCHN) reported a 2.4 and 1.9 percentage point reduction per year in stunting and underweight, respectively (Swindale, Deitchler, Cogill & Marchione, 2004). The MCHN programs combine community development, nutrition education and other health interventions with supplementary feeding using fortified blended foods (FBFs), which are mixes of corn or wheat with vitamins, antioxidants and minerals containing greater than 300 kcal of energy in 100 grams of dry product (Pérez-Expósito & Klein, 2009). Unlike some of the school meal evaluations discussed so far, this evaluation includes children up to five years, solely. The MC FFE program reported greater decreases in stunting but lower decrease in underweight. However, underweight is a composite of stunting and wasting and it is possible that more children were recovered from wasting as a result of the MCHN programs, but the evaluation does not report on this indicator.

A secondary goal of the current assessment was to isolate aspects of the MCFEE program and characteristics of participating institutions which led to or mitigated program impact. Two different outcomes were assessed in logistic models: 1) the odds of changing from being stunted at baseline to being normal by follow-up or improvement and 2) the odds of being stunted at follow-up, regardless of baseline nutritional status. In univariate and multivariate models, location of an institution in the north was associated with improving in nutritional status. Children in the north had higher odds of recovering from stunting. The grams/person/day of food was positively associated with improvements, while the amount of funding was negatively associated with improvements. Controlling for gender increased the significance of the odds ratio for region but made the grams/person/day statistically insignificant and had no impact on funding.

In univariate analyses, attending an institution in the south was associated with increased odds of being stunted at follow-up. Total amount of funding from parents and the local government for school nutrition programs and the grams/person/day were significantly associated with lowered odds of being stunted at follow-up. However, in models adjusting for region and multivariate models, none of the variables, region included, were significantly associated with stunting at follow-up.

The relationship between region and nutritional status could reflect regional difference in political and social conditions. At baseline, there was a higher percentage of stunted children in southern compared to northern institutions, 15.1% compared to 12.2%, although the difference was statistically insignificant. Therefore the relationship between region and nutritional status detected may be due in part to initial differences in nutritional status which persisted even after treatment. However, in addition to fewer children in the south who were initially stunted improving in nutritional status, 13 of the 14 new incidences of stunting that took place after program initiation occurred in the south, further increasing the difference in levels of stunting between the two regions at follow-up. This indicates that there was actually a difference in impact in the two regions that goes beyond initial differences in levels of poor nutritional status. The reason for initial differences in levels of poor nutritional status and for differential impact of the program could be the fact that this program was implemented following violent upheavals that primarily affected the south and led to destructions of homes and displacement of many people (UNICEF, 2011). A World Food Programme (WFP) assessment of food insecurity in Kyrgyzstan conducted March of 2011, nearly a year after the 2010 violent event, found that the most food insecure provinces in the country were Jalalabad, Osh and Batken, all southern provinces (WFP, 2011). The author suggested that observed distributions of food insecurity at that time was most likely due to lingering effects of the violence in 2010. Children in the south who continued to suffer from the impact of those events may have received less nutrition at home, suffered from other adverse conditions, such as illness due to poorer environment and or or have been prevented from attending institutions regularly due to some lingering ethnic tensions. If this were true, children would be less able to utilize nutrition provided in schools, despite the fact that institutions in the south were open for a significantly higher number of days, an average of 48 more days.

It is also possible that difference in impact of nutrition program between the north and south is due to program implementation, including data collection, as completely different teams implemented FFE in the south and the north. Additionally, many institutional and program characteristics assessed, including average dietary diversity at follow-up, grams/person/day and funding from parent and local government, were significantly higher in the north than in the south. The nutrition program funding from parents and the local government is not a direct programmatic component of the MC FFE and could support arguments that program impact was modulated by contextual differences between regions that were out of MC control. However, dietary diversity at follow-up and grams of food provided were direct outcomes and therefore reflect differences in either the effectiveness or data collection of the program between the two regions. Still, the difference in program impact on nutritional status between the regions could possibly reflect a causal relationship between the environment in the south and program implementation.

The relationship between funding and nutritional status could be interpreted in more than one way. Funding was negatively associated with being stunted at follow-up in univariate models and negatively associated with odds of improving from stunting from baseline to follow-up in all models. The north had significantly higher funding for school nutrition than the south. Therefore, negative association with being stunted at follow-up could be a reflection of the relationship between region and stunting. This theory is supported by the fact that adjusting for region only eliminated the relationship between funding and stunting at follow-up. However, as funding was negatively associated with improvement in nutritional status in multivariate models including region, that hypothesis is not fully supported. . A statistical model with more demographic and institutional variables and also with a greater number of institutions to increase sample size is needed to tease out what relationship there may be between parental and government funding for school nutrition and improvements in nutritional status.

While gender was not directly associated with nutritional status in this study, it mitigated the relationship between other variables, especially grams/person/day, and nutritional status. It is not clear why including gender in logistical models made grams/person/day less statistically significant. However, all institutions served relatively high amounts of food daily and the average amount of food provided for both stunted and normal children and those who experience improvement and those who did not exceeded 500 grams daily. This fact could have made detecting the relationship between amount of food provided and nutritional status difficult. The amount of food in this study reflects provision and does not necessarily mean that all children consumed food in equal quantity or for equal number of days, which could also be a reason for the sometimes significant association between food and nutritional status in logistic models.

To the author's knowledge, no other study has reported such high magnitudes of recovery from stunting or decrease in prevalence in stunting as a result of a school meal program. Despite studies indicating that prevalence in stunting increases as children grow older (Petrou & Kupek, 2010), only 2% of all children became stunted between baseline and follow-up, suggesting that MC FFE not only aided recovery in stunting of children but also prevented more children becoming stunted. While community based studies have reported nutrition programs reducing the risk of stunting (Semba et al., 2011), no school meal program reviewed reported on school nutrition programs preventing stunting in children who were not already stunted. The impact observed indicates that provision of commodities in pre-school coupled with nutrition education of stakeholders is able to aid recovery from stunting.

An external report on the current prevalence of each condition assessed on this study by the national statistics committee or by organizations such as UNICEF in the country would confirm if the new levels detected in the FFE sample is greatly different from all other children in the country. Baseline levels of poor nutritional status in the MC FFE sample did closely resemble those reported by UNICEF. In the initial baseline sample (N= 1280), the prevalence of stunting, wasting and underweight were 14.5%, 3.1% and 3.6%, respectively. Per UNICEF, 2%, 3% and 18% of under-five year olds suffer from underweight, wasting and stunting, respectively (www.unicef.org/infobycountry/kyrgzstan_statistics .html) in 2006 through 2010. The rate of stunting by UNICEF is slightly higher than the 13.7 it has reported in the past based on 2006 data (UNICEF 2011), which is closer to the baseline rates in the current study. In the subsample of MC FFE participants with baseline and follow-up measurements, the prevalence of stunting is actually 13.8%, almost exactly similar to the 2006 level. In the absence of more current data for 2011, the prevalence of 14.5% in stunting may be an update for the country, bearing in mind that MC focused on rural children in government funded schools from all seven provinces. The reductions observed in this study, therefore, are likely to resemble real gains for participating children compared to all other children.

Limitation

The most important limitation to this assessment is the lack of a control group, which would allow attribution of changes observed to the MC FFE program. It is not possible to eliminate impact by other organizational activities especially in households, but participation in other humanitarian aid activities by institutions was an exclusion criterion for the program. Kompanion, an independent microfinance and development agency started by MCFFE was simultaneously implementing several programs to aid farmers and livestock owners as well as apple growers. Those activities may have impacted child growth in communities where the two agencies' activities overlapped. Even if potential influence of organizations other MC is ignored, there were four components to the MCFFE program and only two were directly assessed as part of this evaluation. The two other components included the development of vocational schools, which generate profit that is then reinvested into kindergarten school feeding programs, and the provision of grant money for infrastructure repair and renovation at participating institutions. Schools could request money from MC for renovating latrines, windows, doors, kitchen facilities, heating systems, water supply systems and/or furnishing classrooms. In the absence of household or even institutional surveys on morbidity, it is not possible to determine whether or not grant provision had a direct impact on child growth by improving sanitary conditions.

Another limitation of the study was unavailability of demographic and social economic status (SES) variables. The literature indicates that nutritional status, particularly stunting, is influenced by SES, which is frequently a confounder in studies that lack enough variables to fully control for it. The consistent association of region and nutritional outcome observed in the current study could be reflecting differences in SES. However, no data that could be used to assess social demographic variables were available since the program focused on preschools and only collected data about preschools, unless one considers the funding received by institutions, which should have reflected the economic wellbeing of the parents and local government where the institution is located. Also the absence of usable, individual level attendance data and even data on amount and which types of food was actually consumed, rather than provided, by children at institutions make it harder to argue against home factors, rather than school meal programs, having direct impact on growth.

Errors in data recording and measurement could also be in effect. Although largely ignored in the field, it has been recommended that measures be taken to avoid two types of measurement errors that could occur in growth monitoring (Ulijaszek & Kerr, 1999). One type of error is explained by the fact that if an individual or two different individuals measures the same child multiple times, the measurement obtained are likely to be slightly different, leading to imprecision. Another source of error occurs in having error due to the technology used or inaccuracy in reading of measurements by the researchers. Training on proper measurement procedure and standardized methods can reduce but not eliminate this error. While there is no way to eliminate imprecision, taking multiple measurements of the same child would allow for calculation and reporting of the amount of error. In the current study, as in many others, measurements were taken only once for each child using a simple ruler, rather than a stadiometer, which is recommended by the World Health Organization (WHO). This practice may not be easily altered, however, due to time and funding considerations. In addition to potential errors in field, some errors in data recording could have occurred during cleanup and merging of various excel documents. Whenever a measurement did not seem probable, data was double checked by tracing to original recorded measurements and accompanying dates of birth.

Finally the construction of some of the variables in this assessment for statistical analysis could have adversely impacted ability to detect associations between variables and nutritional outcome. For example, the dietary diversity variable was constructed with the logic that foods eaten on three or more days are more likely to have been consumed in adequate quantities. Although this is not the first time that three days out of seven have been used in assessing dietary diversity scores, the decision to use this method was completely discretionary. Sensitivity assessments using only foods eaten at least once in seven days and even using 12 instead of eight food groups could shed more light on whether or not this was the best approach.

Recommendation

Recommendations to the MC FFE program primarily concern improving data monitoring and recording. The program clearly has potential to significantly improve child health, but efforts should be made to improve data quality. Specifically, more direct and accurate monitoring of enrollment and attendance, direct observation and recording of amounts consumed by each child, investment in a stadiometer and training of data monitors could significantly improve the accuracy of data collected as well as attribution of results. In order to enable attribution, future programs should include a control group and additional demographic data from households of children included in the study.

The MC FFE program has many components that could be rich sources of data. Future assessments should include surveys on morbidity in order to better assess the impact of infrastructure renovations on growth. Assessment of the menus used in institutions would also allow for more accurate computation of total calories and the amount of different vitamins and minerals that are consumed by children, which would be a more direct assessment of the impact of the nutrition education activities.

Continued implementation of the MC FFE program should be done with careful attention to how meals served to children impact obesity in the population. In the current study obesity increased in prevalence. The literature indicates that excessive gains in weight following early childhood malnutrition, especially stunting, can lead to very detrimental health conditions, including heart failure. Excess weight gain could be avoided by closely monitoring and making recommendations for amounts and types of foods to be served to children and by promoting physical activity in children.

Conclusion

The goal of this thesis was to assess the impact of the MC FFE pre-school feeding program on growth in order to contribute to the literature on undernutrition in an area where there is an incredible dearth. Overall, the results of the current assessment indicate that pre-school-based nutrition programs can significantly improve child nutritional outcome. The high rate of recovery from stunting is particularly significant as it is generally assumed that recovery from stunting is not possible beyond two or three years in age. The lack of a control group means that this study cannot be generalized to populations that do not share similar contexts as the children in this study. However, as results were changes in the same children before and after the nutrition program, this study indicates that given the proper context, nutrition interventions provided in preschool settings can in fact lead to large improvements in nutritional status.MC FFE should continue implementing its nutrition programs in school settings but with careful attention to design, so that the impact of these programs on children can be better articulated. Additionally, evaluation of more food for education programs in preschool children should be conducted so as to test the robustness of program impacts across differing political, economic and cultural settings.

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Table S3.2 Cross tabulation of nutritional outcome indicators and select variables at baseline

A. Region

Variables		**North**	**South**	**P-value**
Stunted	Count	41	63	0.26
	%	12.2	15.1	
Underweight	Count	9	15	0.48
	%	2.7	3.6	
Wasted	Count	7	19	0.07
	%	2.1	4.5	
Obese	Count	6	4	0.35
	%	1.8	1	

B. Self-rating on whether or not school infrastructure required repair

Variables		**Normal**	**Need repair**	**P-value**
Stunted	Count	44	60	0.11
	%	11.8	15.8	
Underweight	Count	12	12	0.97
	%	3.2	3.2	
Wasted	Count	17	9	0.1
	%	4.5	2.4	
Obese	Count	1	9	0.02
	%	0.3	2.4	

C. Gender

Variables		**Female**	**Male**	**P-value**
Stunted	Count	47	57	0.55
	%	13	14.5	
Underweight	Count	9	15	0.3
	%	2.5	3.8	
Wasted	Count	10	16	0.33
	%	2.8	4.1	
Obese	Count	2	8	0.11
	%	0.6	2	

D. Province

Province		Stunted	Normal	p-value
Chui	Count	15	168	<0.01
	%	8.2	91.8	
Naryn	Count	11	50	
	%	18	82	
Talas	Count	9	13	
	%	40.9	59.1	
Issyk-Kul	Count	6	64	
	%	8.6	91.4	
Batken	Count	12	82	
	%	12.8	87.2	
Jalal-Abad	Count	18	125	
	%	12.6	87.4	
Osh	Count	33	148	
	%	18.2	81.8	

Note: The expected values were lower than 5 in one cell (7.1%)

Table S3.3 Bivariate comparison of those with normal and abnormal status at baseline for select continuous variables

A. Stunting status

	Stunted		Normal			
	N	Mean ± SD	N	Mean ± SD	t	p-value
Age at baseline	104	57.12	650	55.81	1.27	0.2
Funding for food program	104	23.62	650	26.73	-3.69	<0.01
Baseline dietary diversity	104	5.51	650	5.9	-2.96	<0.01

B. Wasting status

Variables	**Wasted**		**Normal**			
	N	Mean ± SD	N	Mean ± SD	t	p-value
Age at baseline	26	59.35±9.28	728	55.87±9.76	1.87	0.07
Funding for food program	26	28.35±6.97	728	26.23±8.77	1.51	0.14
Baseline dietary diversity	26	6.46±0.99	728	5.83±1.27	2.51	0.01

C. Underweight status

	Wasted		Normal			
	N	Mean ± SD	N	Mean ± SD	t	p-value
Age at baseline	24	61.74±8.53	730	55.81±9.74	2.95	<0.01
Funding for food program	24	25.22±8.55	730	26.34±1.44	-0.62	0.54
Baseline dietary diversity	24	5.79±1.44	730	5.85±1.26	-0.22	0.81

D. Obese status

	Obese		Normal			
	N	Mean ± SD	N	Mean ± SD	t	p-value
Age at baseline	10	55.79±10.18	744	55.99±9.76	-0.07	0.95
Funding for food program	10	28.36±10.31	744	26.27±8.70	0.75	0.45
Baseline dietary diversity	10	6.10±1.10	744	5.85±1.27	0.63	0.53